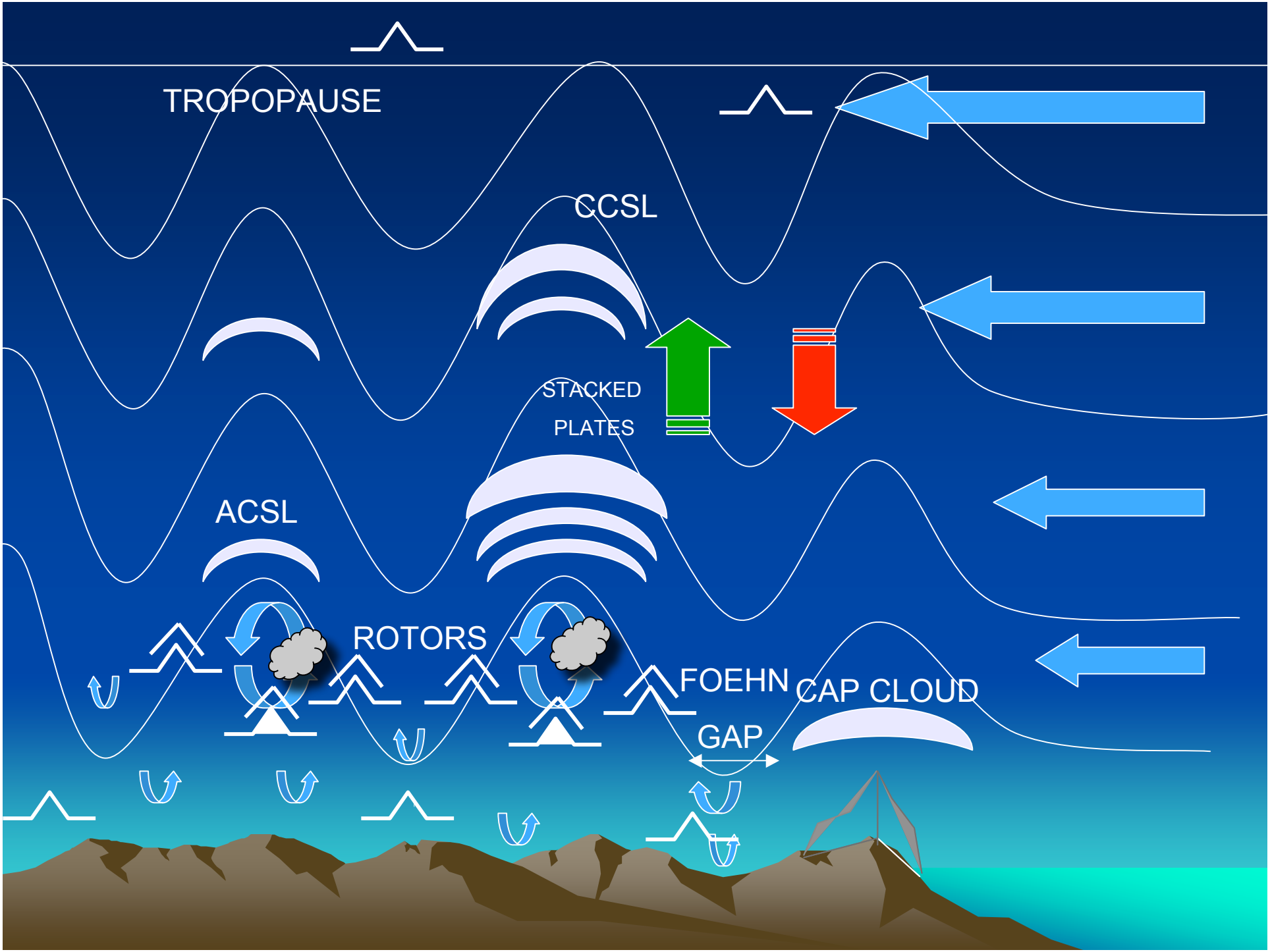
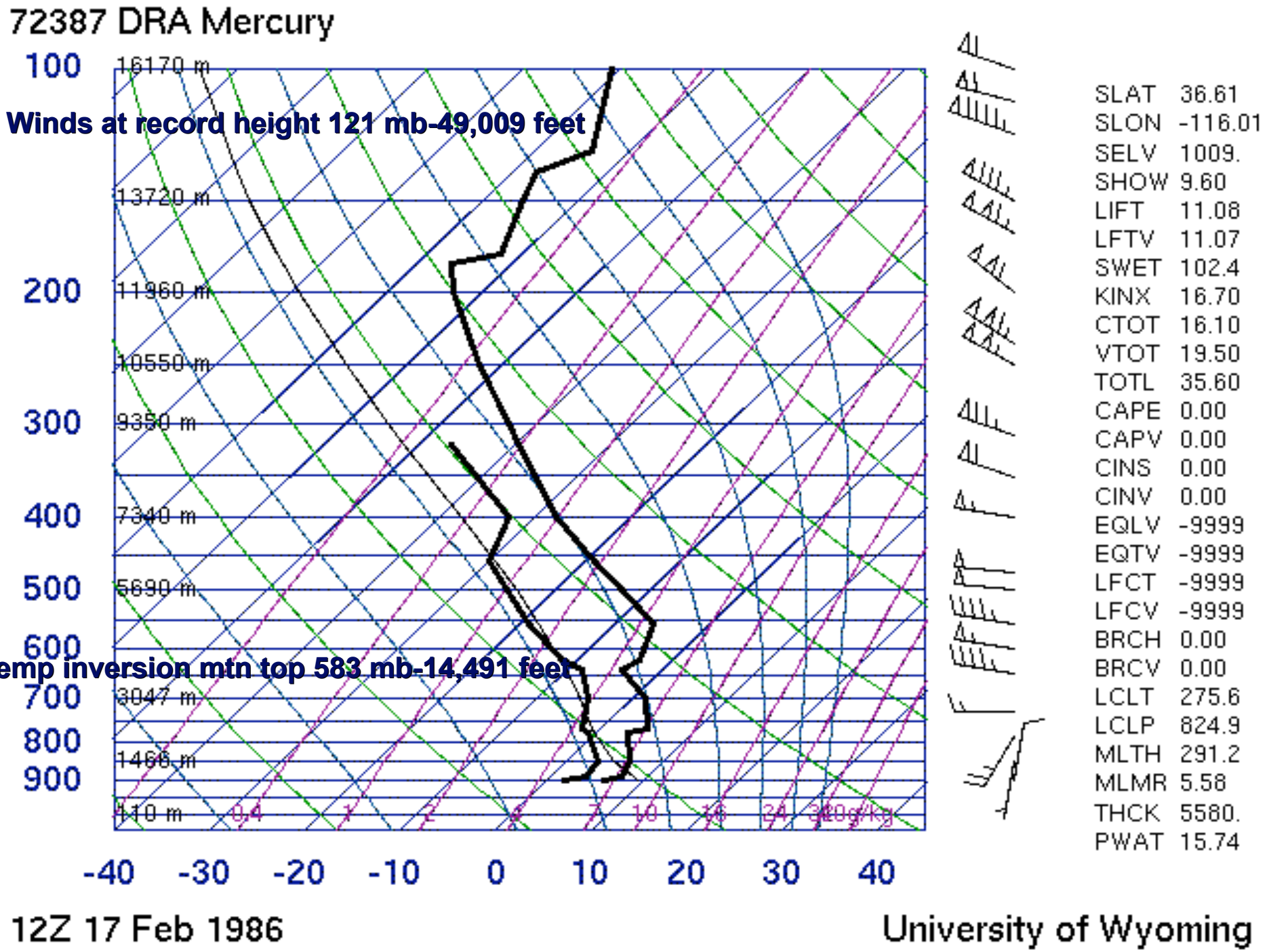
Wave Meteorology and Soaring

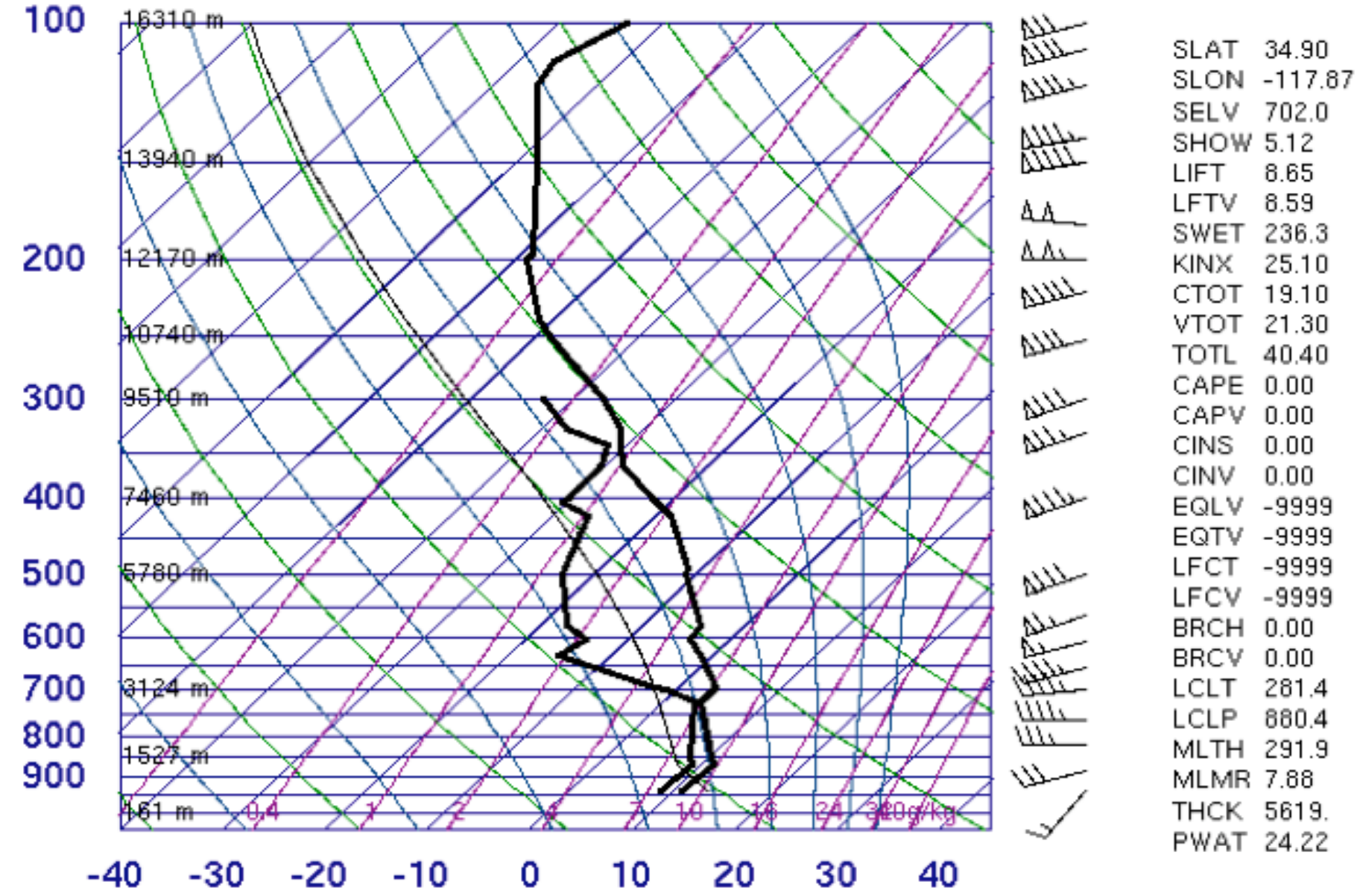
Scott Wiley
Meteorologist, Tybrin, Inc
NASA Dryden Flight Research Center


GA


TROPOPAUSE
CCSL
STACKED
PLATES
ACSL
ROTORS
FOEHN
CAP CLOUD
GAP


72387 DRA Mercury
Winds at record height 121 mb-49,009 feet
Temp inversion mtn top 583 mb-14,491 feet
100
200
300
400
500
600
700
800
900
16170 m
13720 m
11960 m
10550 m
9350 m
7340 m
5690 m
3047 m
1466 m
110 m
-40 -30 -20 -10 0 10 20 30 40
SLAT 36.61
SLON -116.01
SELV 1009.
SHOW 9.60
LIFT 11.08
LFTV 11.07
SWET 102.4
KINX 16.70
CTOT 16.10
VTOT 19.50
TOTL 35.60
CAPE 0.00
CAPV 0.00
CINS 0.00
CINV 0.00
EQLV -9999
EQTV -9999
LFCT -9999
LFCV -9999
BRCH 0.00
BRCV 0.00
LCLT 275.6
LCLP 824.9
MLTH 291.2
MLMR 5.58
THCK 5580.
PWAT 15.74
12Z 17 Feb 1986
University of Wyoming

72381 EDW Edwards Afb



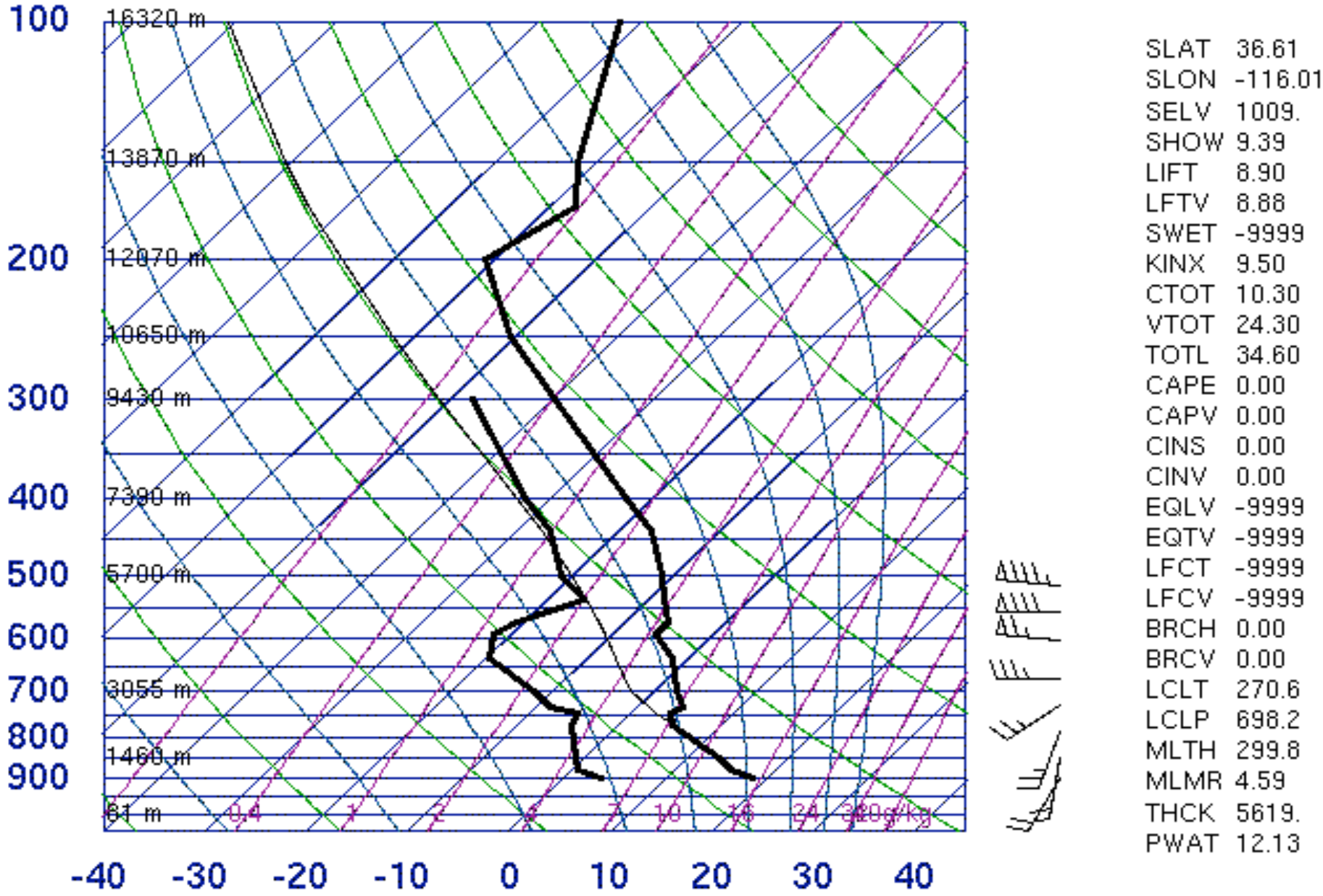
SLAT	34.90
SLON	-117.87
SELV	702.0
SHOW	5.12
LIFT	8.65
LFTV	8.59
SWET	236.3
KINX	25.10
CTOT	19.10
VTOT	21.30
TOTL	40.40
CAPE	0.00
CAPV	0.00
CINS	0.00
CINV	0.00
EQLV	-9999
EQTV	-9999
LFCT	-9999
LFCV	-9999
BRCH	0.00
BRCV	0.00
LCLT	281.4
LCLP	880.4
MLTH	291.9
MLMR	7.88
THCK	5619.
PWAT	24.22

12Z 18 Feb 1986

University of Wyoming

Prev Next Stop Start Slower Faster Delete

72387 DRA Mercury



SLAT	36.61
SLON	-116.01
SELV	1009.
SHOW	9.39
LIFT	8.90
LFTV	8.88
SWET	-9999
KINX	9.50
CTOT	10.30
VTOT	24.30
TOTL	34.60
CAPE	0.00
CAPV	0.00
CINS	0.00
CINV	0.00
EQLV	-9999
EQTV	-9999
LFCT	-9999
LFCV	-9999
BRCH	0.00
BRCV	0.00
LCLT	270.6
LCLP	698.2
MLTH	299.8
MLMR	4.59
THCK	5619.
PWAT	12.13

00Z 18 Feb 1986

University of Wyoming


This and the next 15 photos are courtesy of and copyrighted by Bob Harris on
February 17,1986
Record Soaring Wave Conditions


~7,000 feet on tow


~9,000 feet
OXYGEN REGULATOR
PRESSURE DEMAND
FLOW
EMERGENCY
NORMAL
TEST MASK
OXYGEN P.S.I.
SUPPLY ON
NORMAL OXYGEN
OFF
OXYGEN REGULATOR
PRESSURE DEMAND
OXYGEN P.S.I.
FUSE


~10,000 feet
GEN REGULATOR
FLOW


~14,000 feet


~15,000 feet


~16,000 feet


~15,000 feet


~24,000 feet

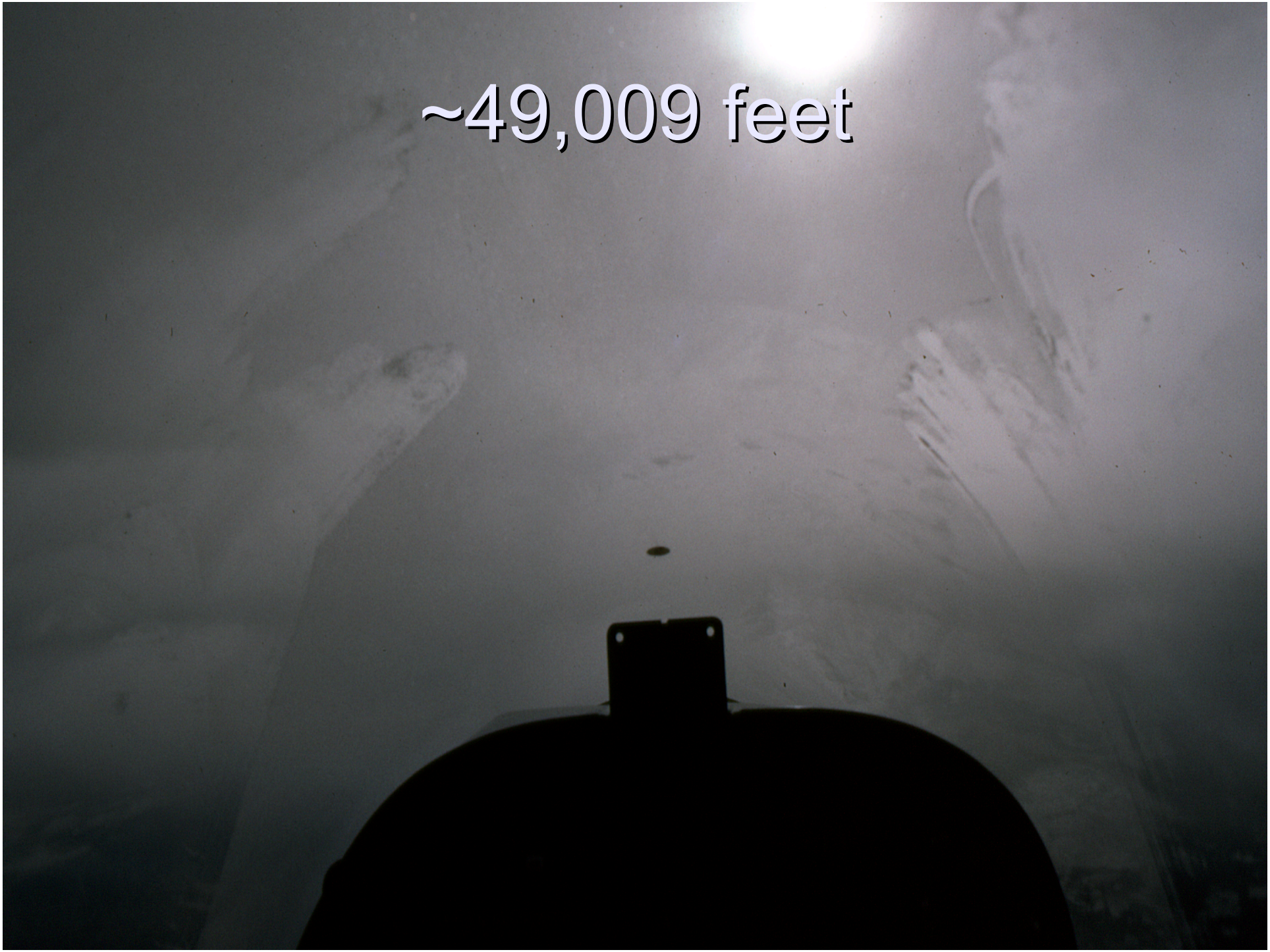

~25,000 feet


~18,000 feet

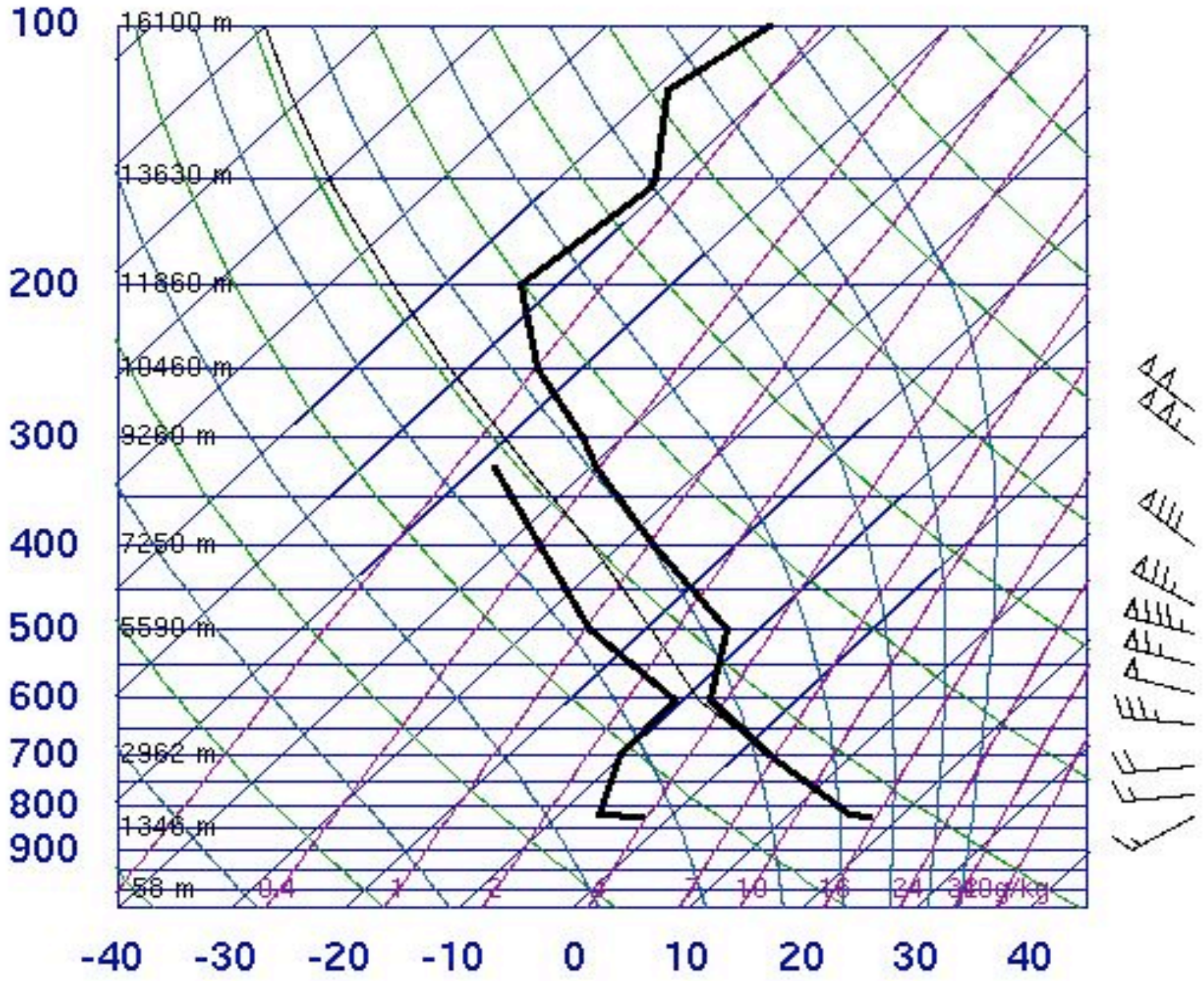

~20,000 feet


~30,000 feet


~35,000 feet


~49,009 feet

72469 DNR Denver

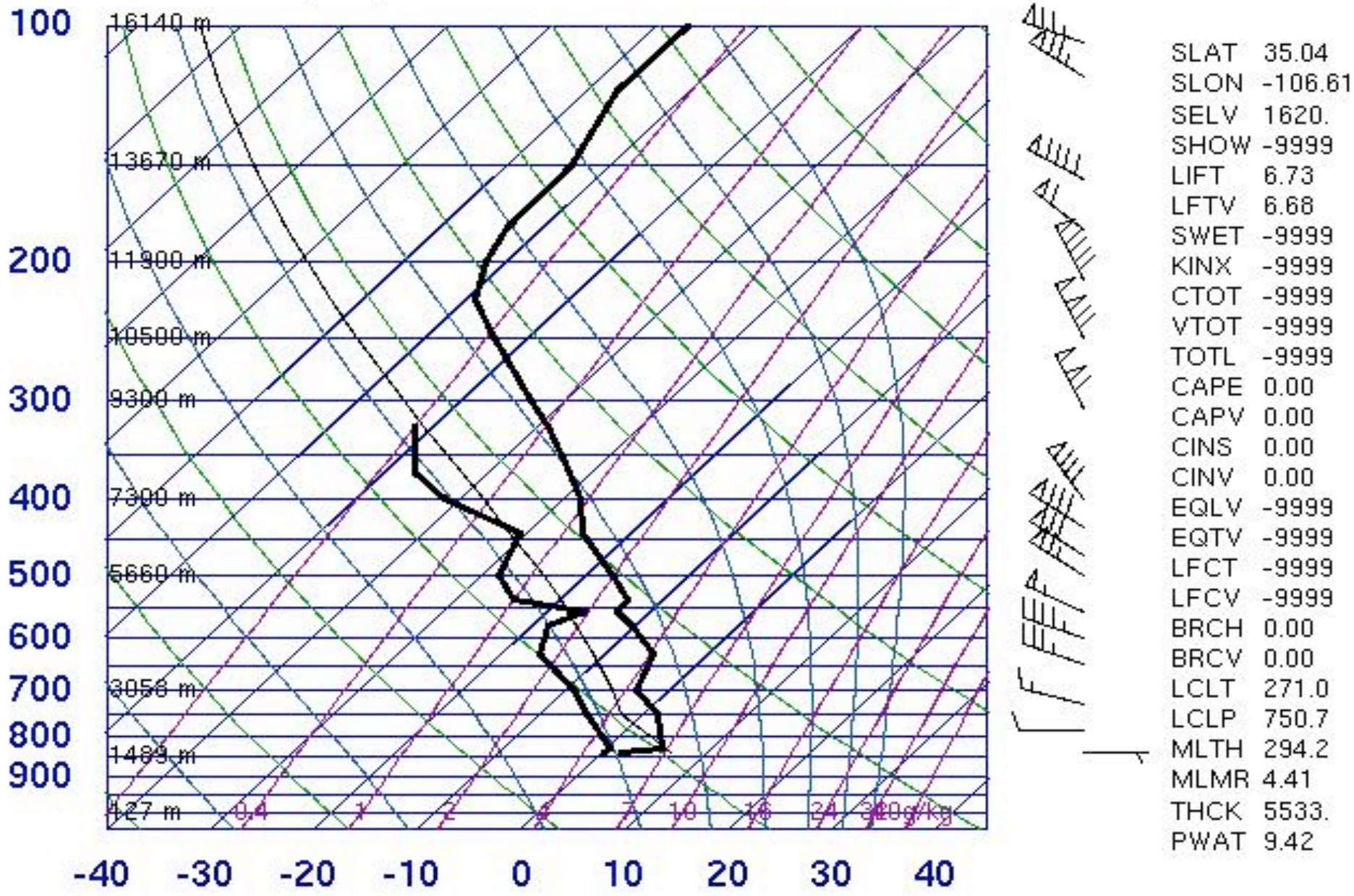


SLAT	39.75
SLON	-104.87
SELV	1625.
SHOW	-9999
LIFT	6.68
LFTV	6.59
SWET	-9999
KINX	-9999
CTOT	-9999
VTOT	-9999
TOTL	-9999
CAPE	0.00
CAPV	0.00
CINS	0.00
CINV	0.00
EQLV	-9999
EQTV	-9999
LFCT	-9999
LFCV	-9999
BRCH	0.00
BRCV	0.00
LCLT	262.2
LCLP	584.6
MLTH	305.7
MLMR	2.87
THCK	5648.
PWAT	8.95

00Z 18 Feb 1986

University of Wyoming

72365 ABQ Albuquerque

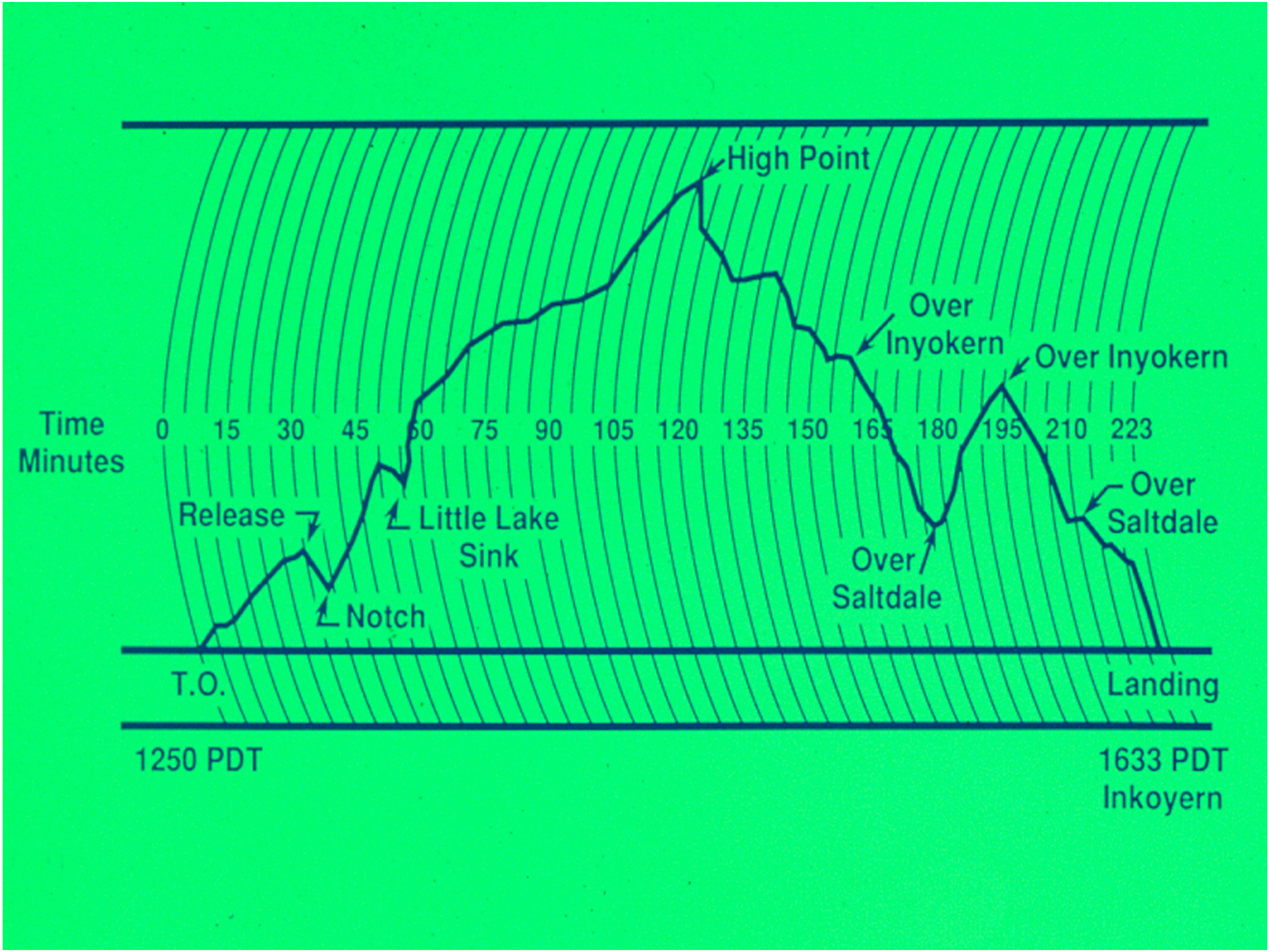


SLAT	35.04
SLON	-106.61
SELV	1620.
SHOW	-9999
LIFT	6.73
LFTV	6.68
SWET	-9999
KINX	-9999
CTOT	-9999
VTOT	-9999
TOTL	-9999
CAPE	0.00
CAPV	0.00
CINS	0.00
CINV	0.00
EQLV	-9999
EQTV	-9999
LFCT	-9999
LFCV	-9999
BRCH	0.00
BRCV	0.00
LCLT	271.0
LCLP	750.7
MLTH	294.2
MLMR	4.41
THCK	5533.
PWAT	9.42

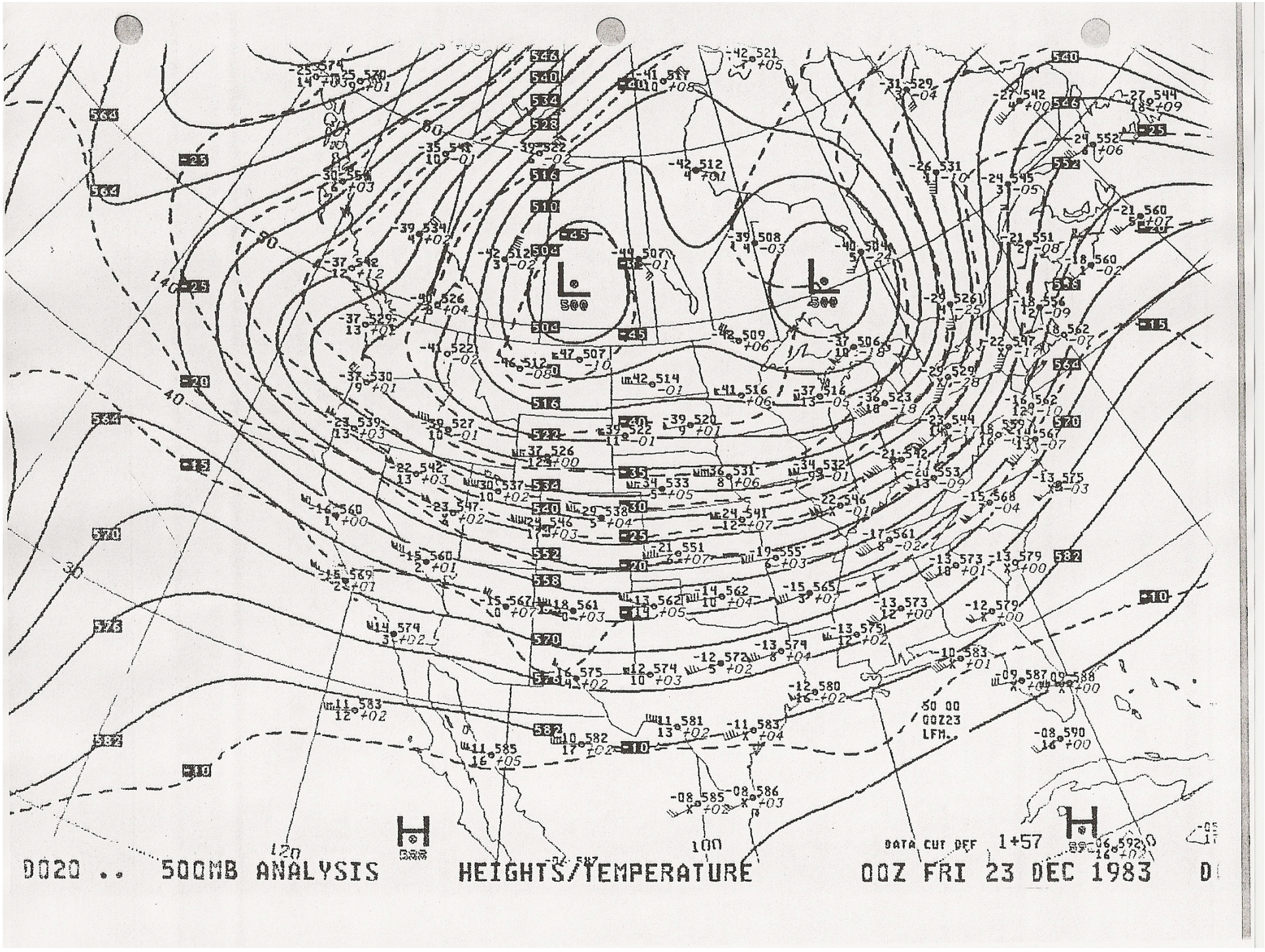
12Z 17 Feb 1986

University of Wyoming

Inyokern, Feb 17, 1986


High Point
Over Inyokern
Over Inyokern
Time Minutes
0 15 30 45 60 75 90 105 120 135 150 165 180 195 210 223
Release
Little Lake Sink
Notch
Over Saltdale
Over Saltdale
T.O.
Landing
1250 PDT
1633 PDT
Inkoyern


Dec 22, 83 FL350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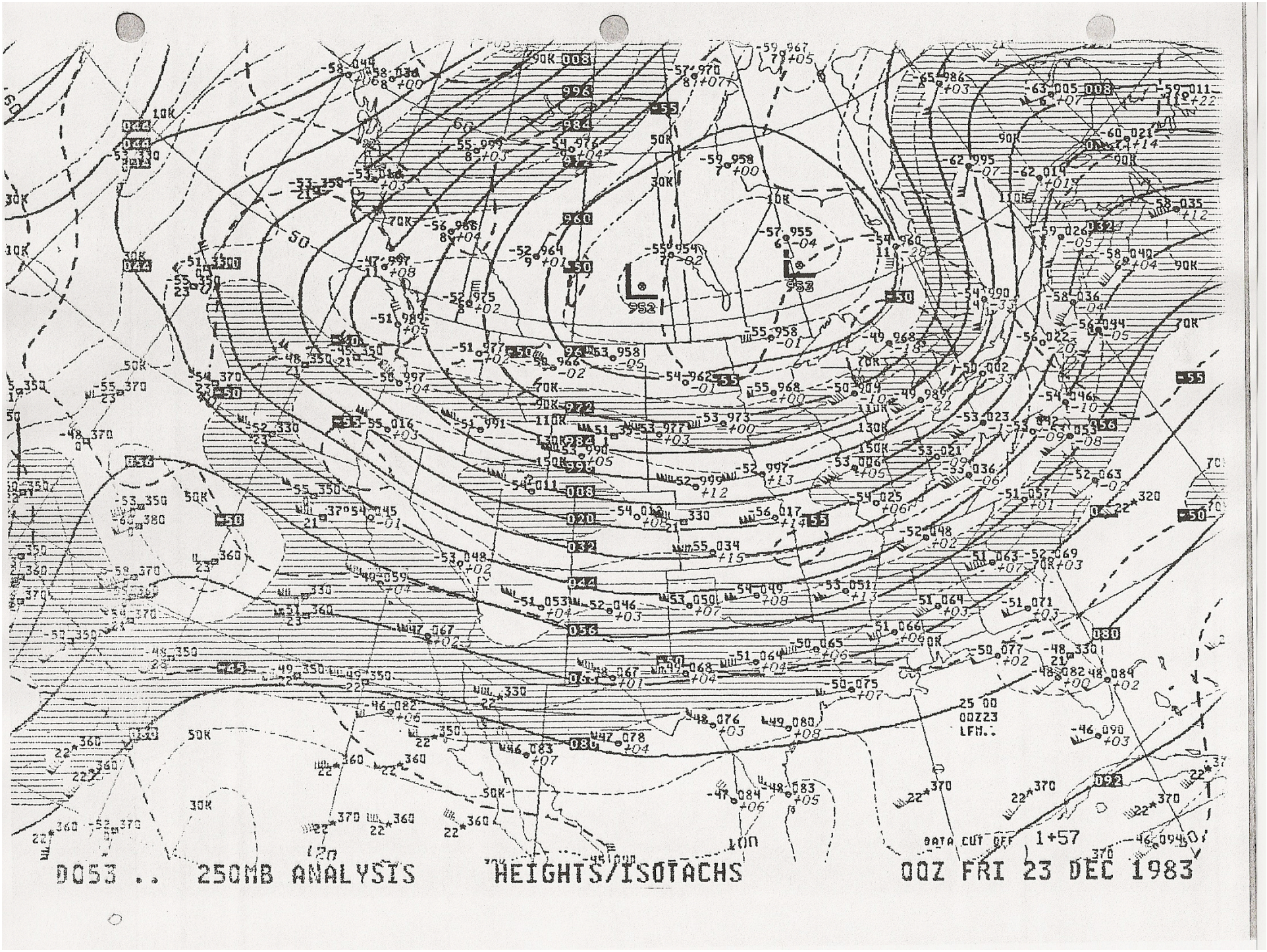
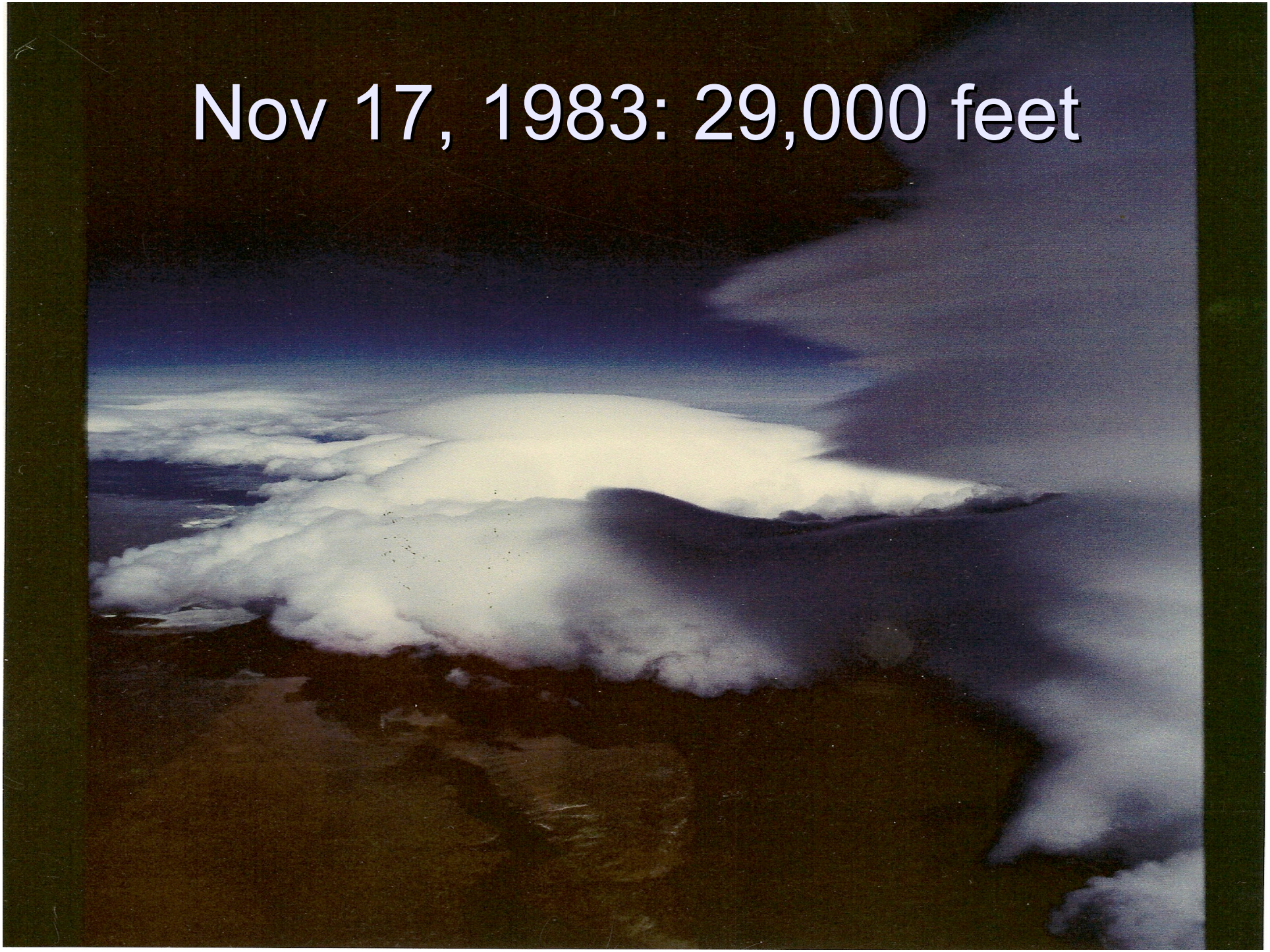
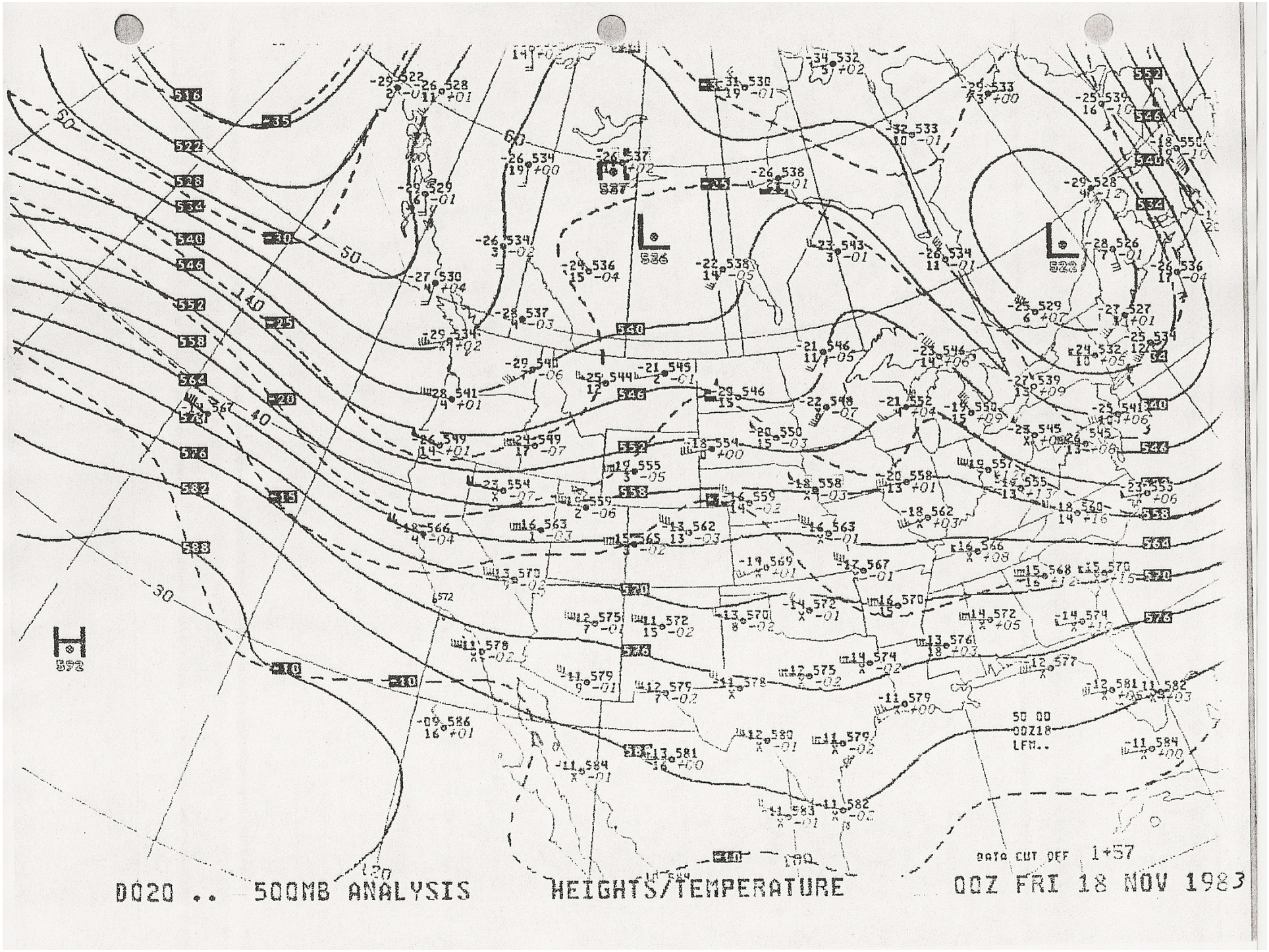
DATA CUT OFF 1+57
00 00
00Z23
LFM.


DOSS .. 250MB ANALYSIS HEIGHTS/ISOTACHS 00Z FRI 23 DEC 1983
DATA CUT OFF 1+57


Nov 17 1983: 30,000 feet


Nov 17, 1983: 29,000 feet


D020 .. 500MB ANALYSIS HEIGHTS/TEMPERATURE
00Z FRI 18 NOV 1983
DATA CUT OFF 1457
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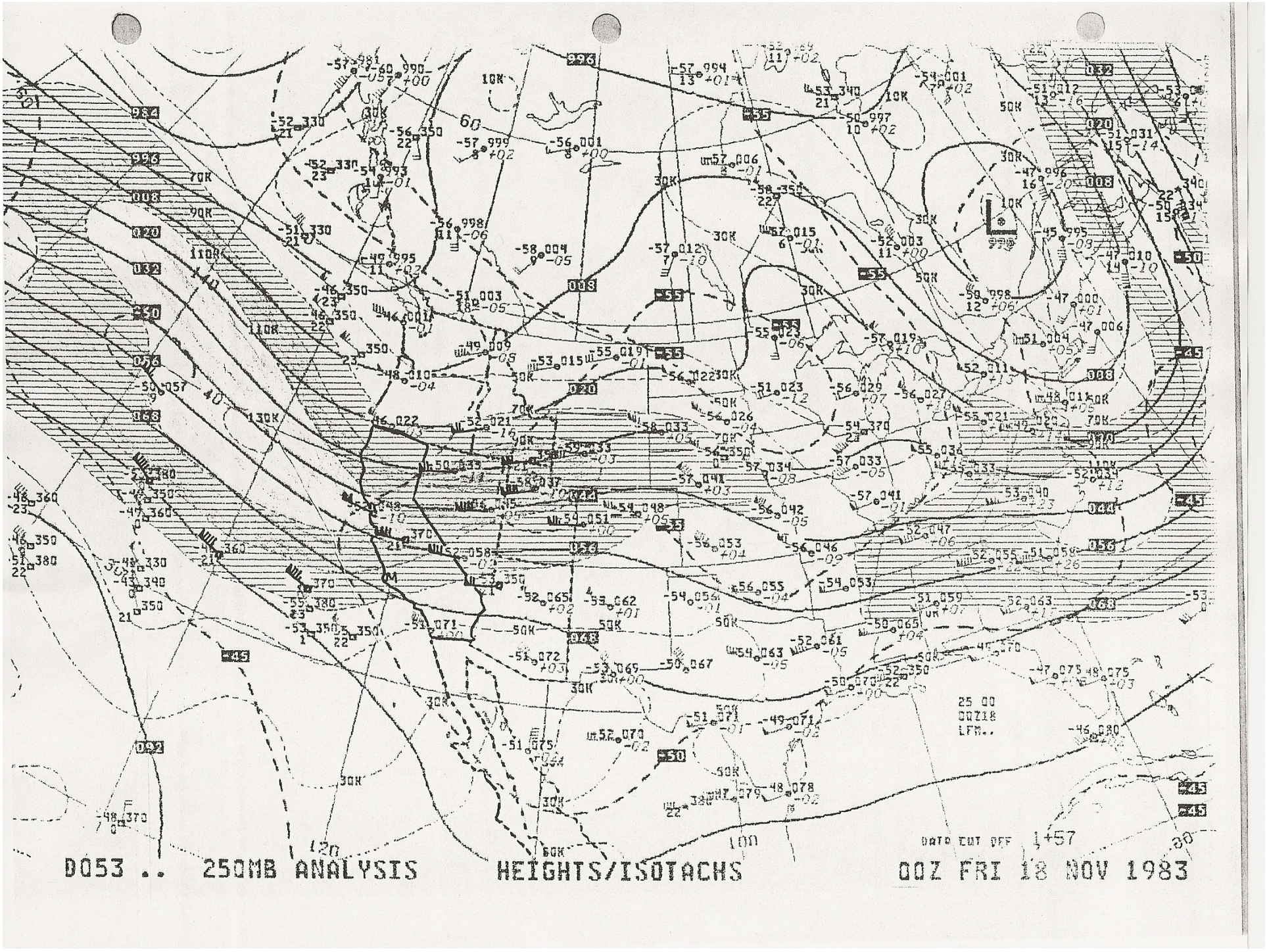
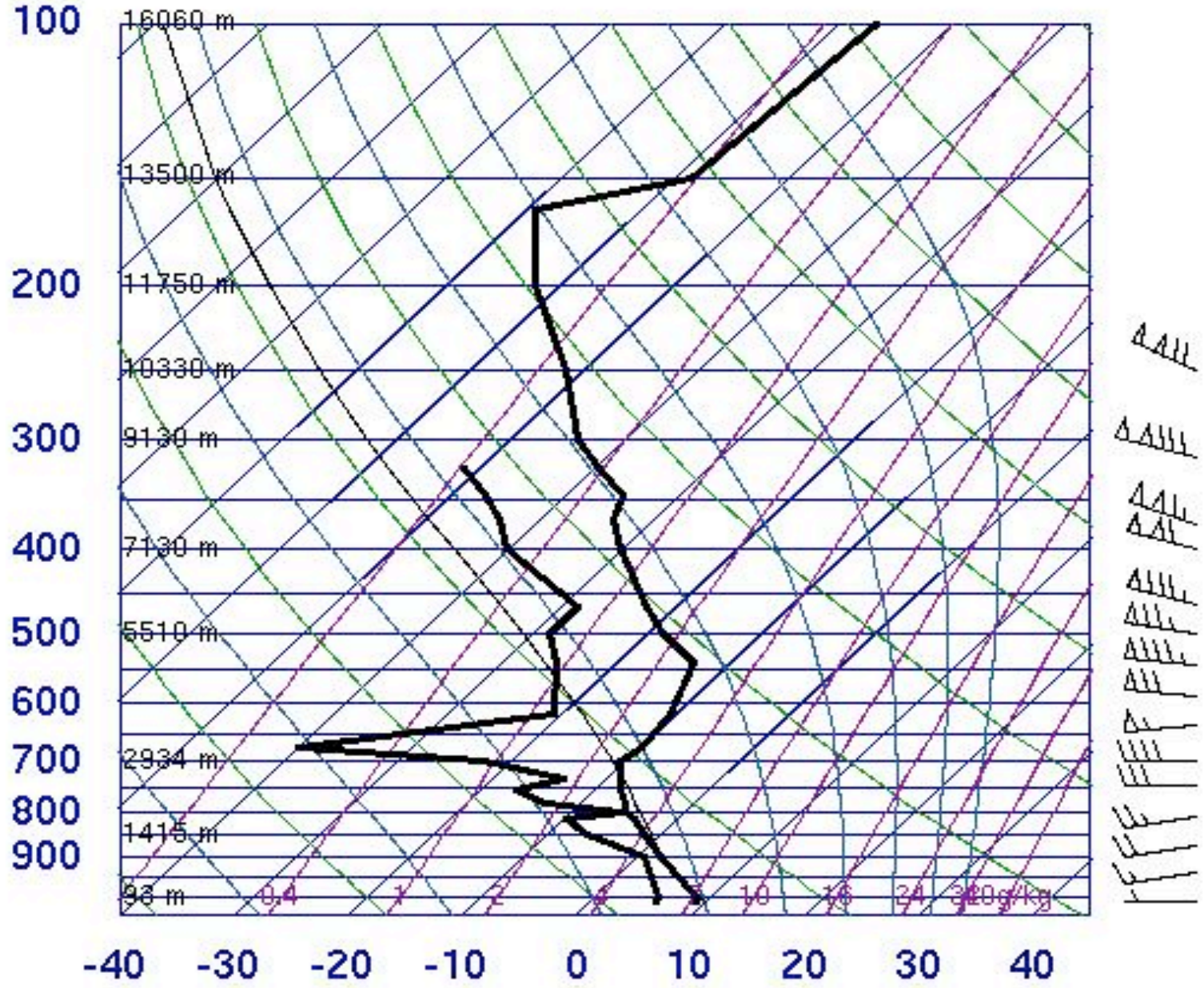
00Z18
LFM..


D053 .. 250MB ANALYSIS HEIGHTS/ISOTACHS
00Z FRI 18 NOV 1983
DATA CUT OFF 1+57


Mar 27, 1985: 34,000


Mojave: Mar 27, 1985: 19,000 SE

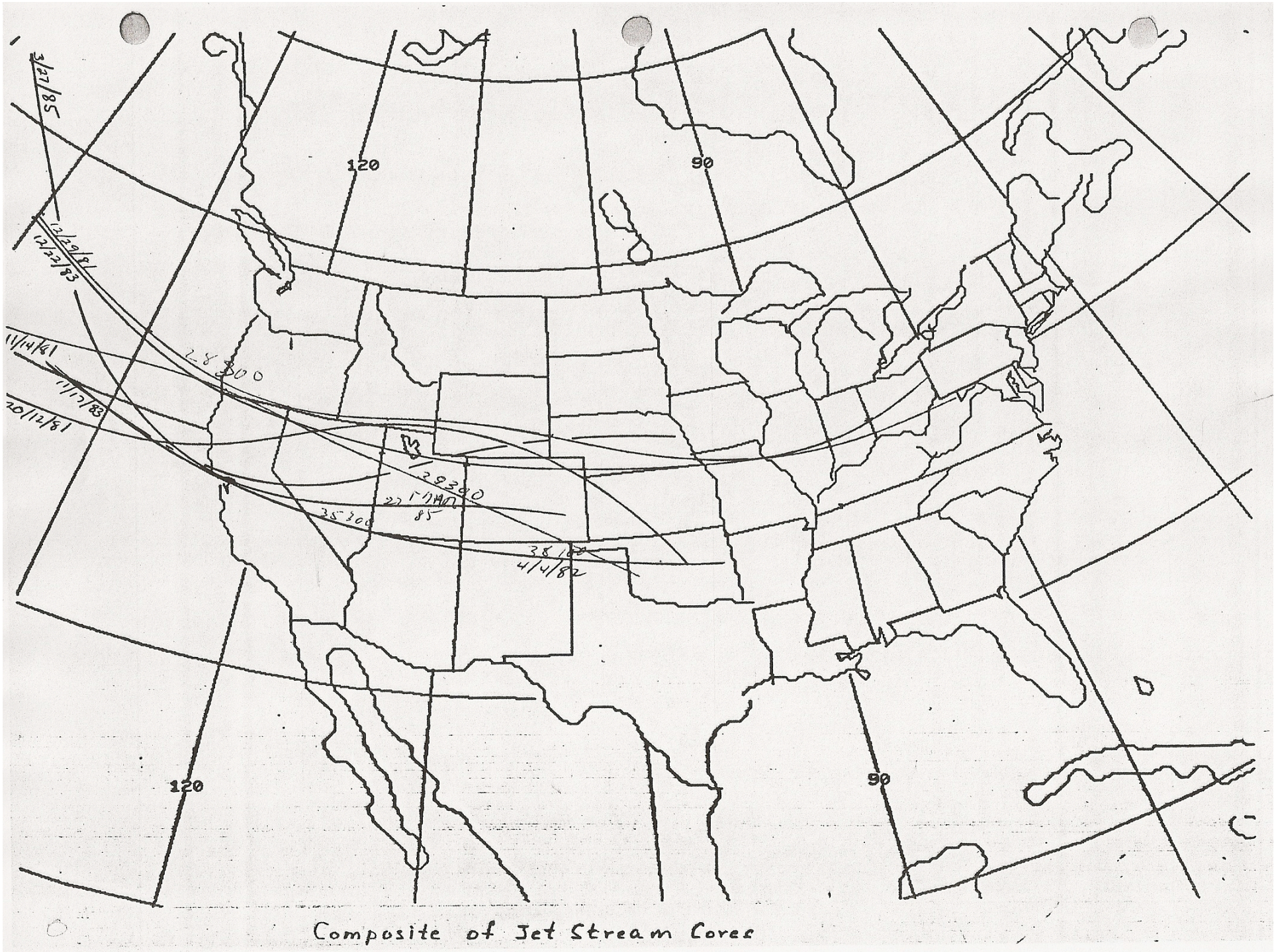
72493 OAK Oakland Int



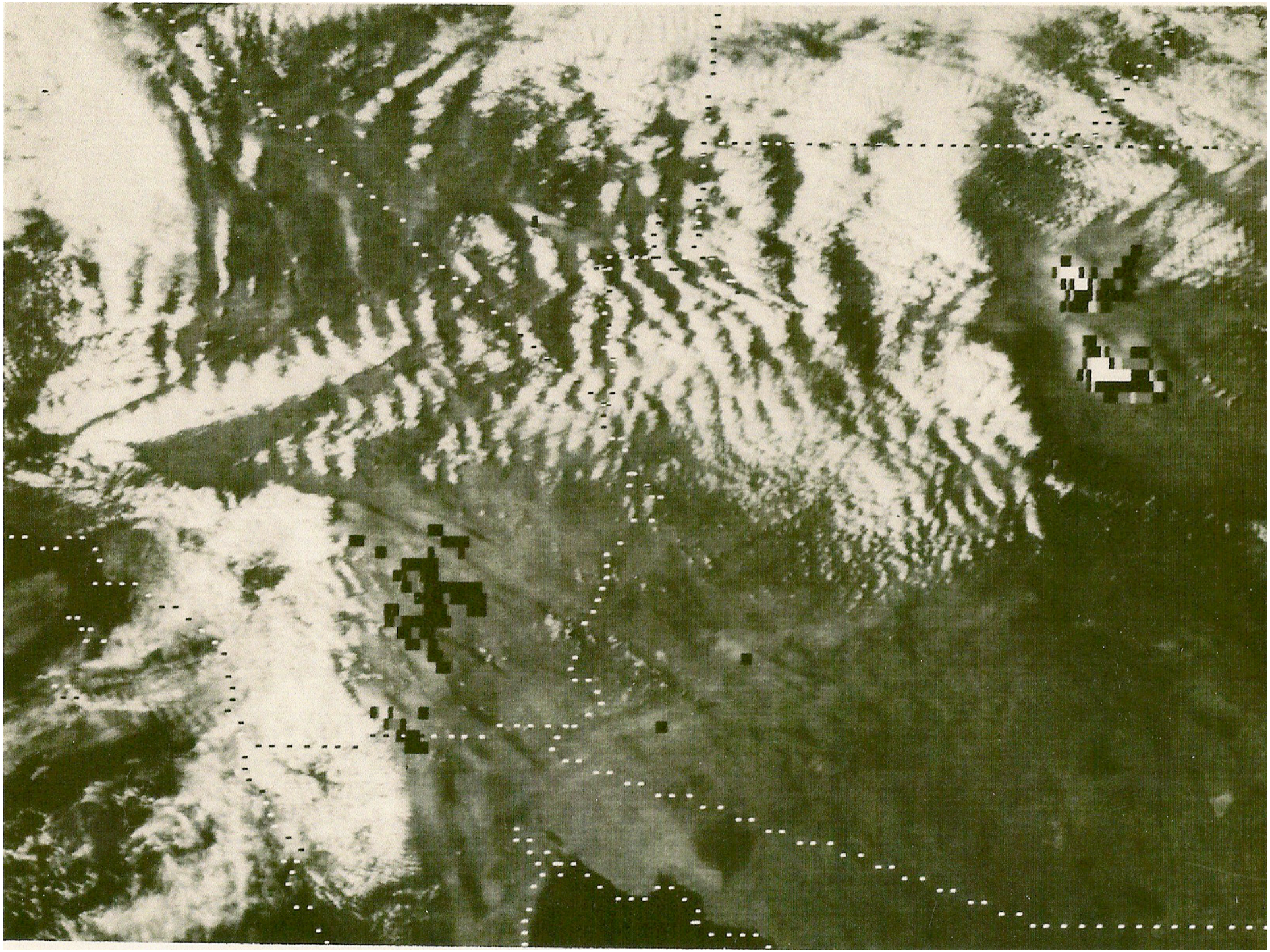
SLAT	37.72
SLON	-122.20
SELV	3.00
SHOW	15.65
LIFT	12.33
LFTV	12.36
SWET	119.0
KINX	-1.40
CTOT	12.10
VTOT	17.00
TOTL	29.10
CAPE	38.90
CAPV	51.68
CINS	-6.82
CINV	-5.55
EQLV	724.6
EQTV	715.6
LFCT	897.5
LFCV	902.0
BRCH	0.38
BRCV	0.51
LCLT	276.9
LCLP	936.6
MLTH	282.2
MLMR	5.41
THCK	5417.
PWAT	13.06

12Z 27 Mar 1985

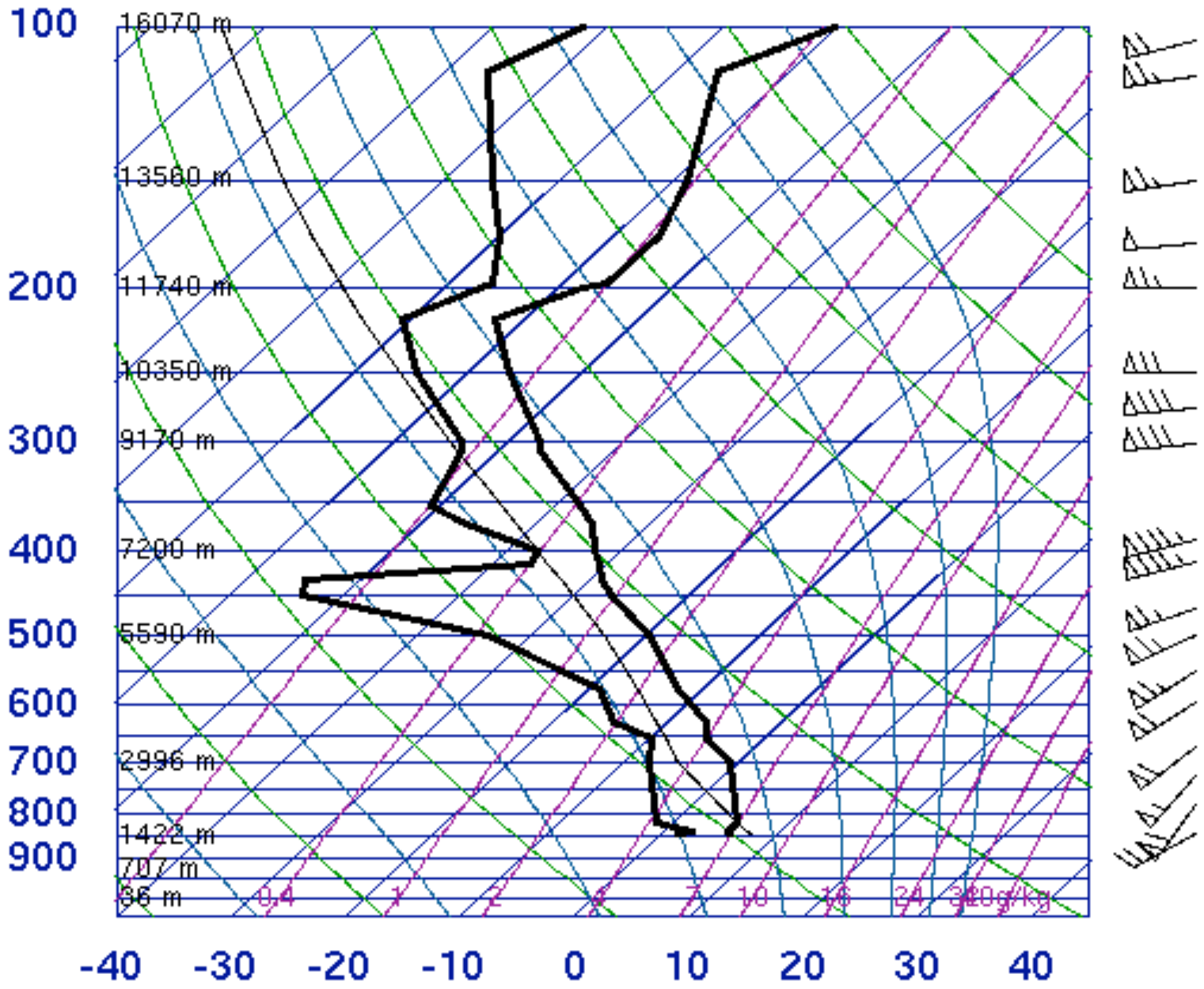
University of Wyoming



Composite of Jet Stream Cores



72489 REV Reno



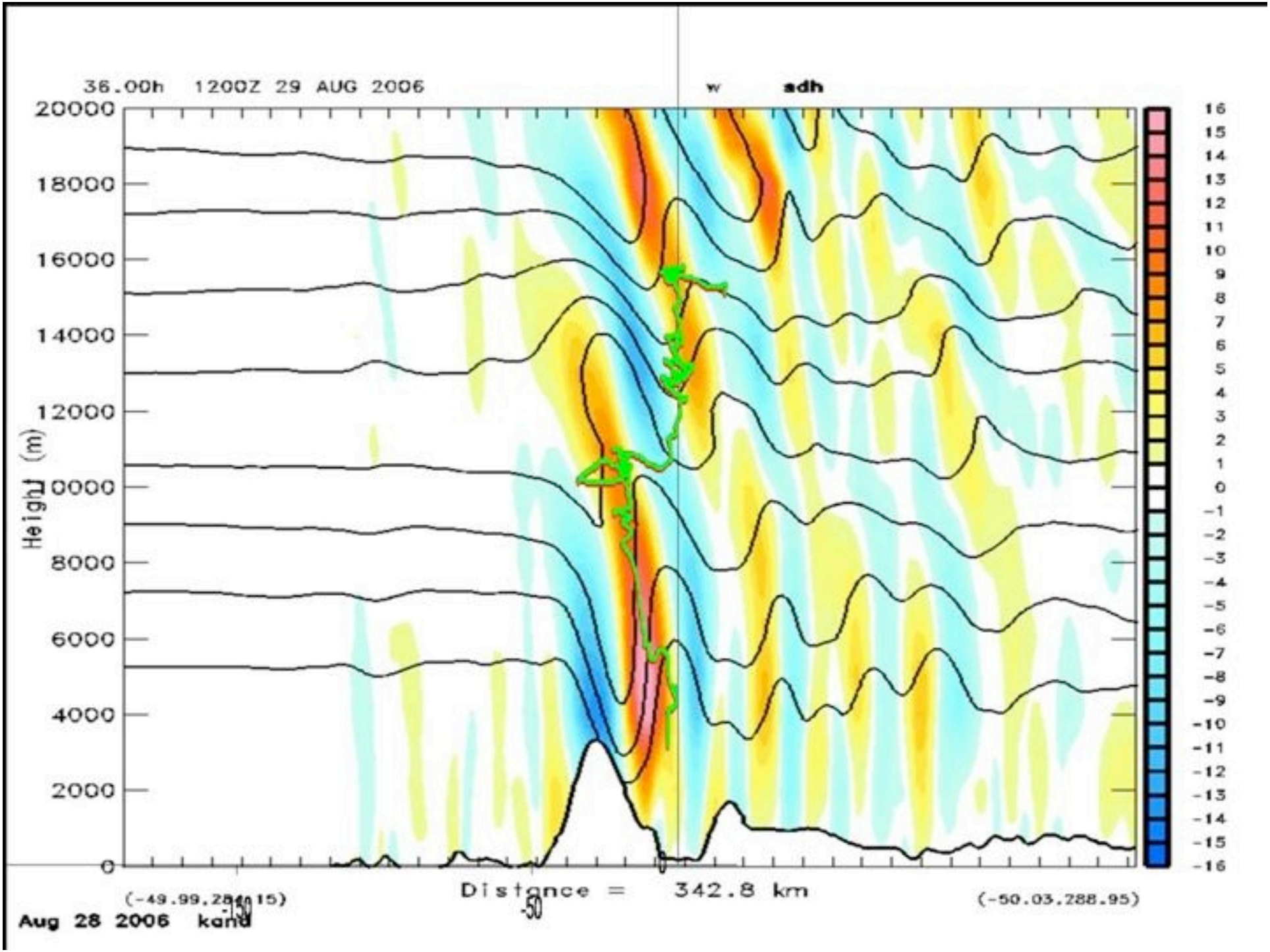
SLAT	39.56
SLON	-119.80
SELV	1516.
SHOW	-9999
LIFT	3.91
LFTV	3.80
SWET	-9999
KINX	-9999
CTOT	-9999
VTOT	-9999
TOTL	-9999
CAPE	0.00
CAPV	0.00
CINS	0.00
CINV	0.00
EQLV	-9999
EQTV	-9999
LFCT	-9999
LFCV	-9999
BRCH	0.00
BRCV	0.00
LCLT	270.8
LCLP	741.9
MLTH	294.9
MLMR	4.40
THCK	5554.
PWAT	9.53

12Z 03 Mar 1999

University of Wyoming

Trapped mountain waves


LV-MFU
AS ARGENTINAS


36.00h 1200Z 29 AUG 2006
w
adh
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
Height (m)
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
-13
-14
-15
-16
(-49.99,288.15)
Distance = 342.8 km
(-50.03,288.95)
-150
-50
Aug 28 2006 kand

“Never fly downwind in a mountain wave” Paul Bickle

- Einar Enevoldson and Steve Fossett moved downwind to get 50,699 feet in the Andes mountains (Aug 29, 2006)
- Bob Harris used S Sierras for 49,009 feet (Feb, 17, 1986)
- Joach Kuettner’s downwind dash is still doable but has not been realized YET! (3 very high climbs and dash)
- Trapped mountain waves may be a factor in the downwind dash with a higher workload
- Night launches, ATC cooperation, faster, strong sailplanes will all play a role wherever in the world the next record in mountain wave is set

WESTERN UNION TELEGRAM

WESTERN UNION TELEGRAM

WESTERN UNION TELEG

WUA018 LG148 L LLU097 DLPD

TDLPWS WASHINGTON DC14 946A PST

PAULF BIKLE JR, DO NOT FWD

44926 NORTH RAZSACK AVE LANCASTER CALIF

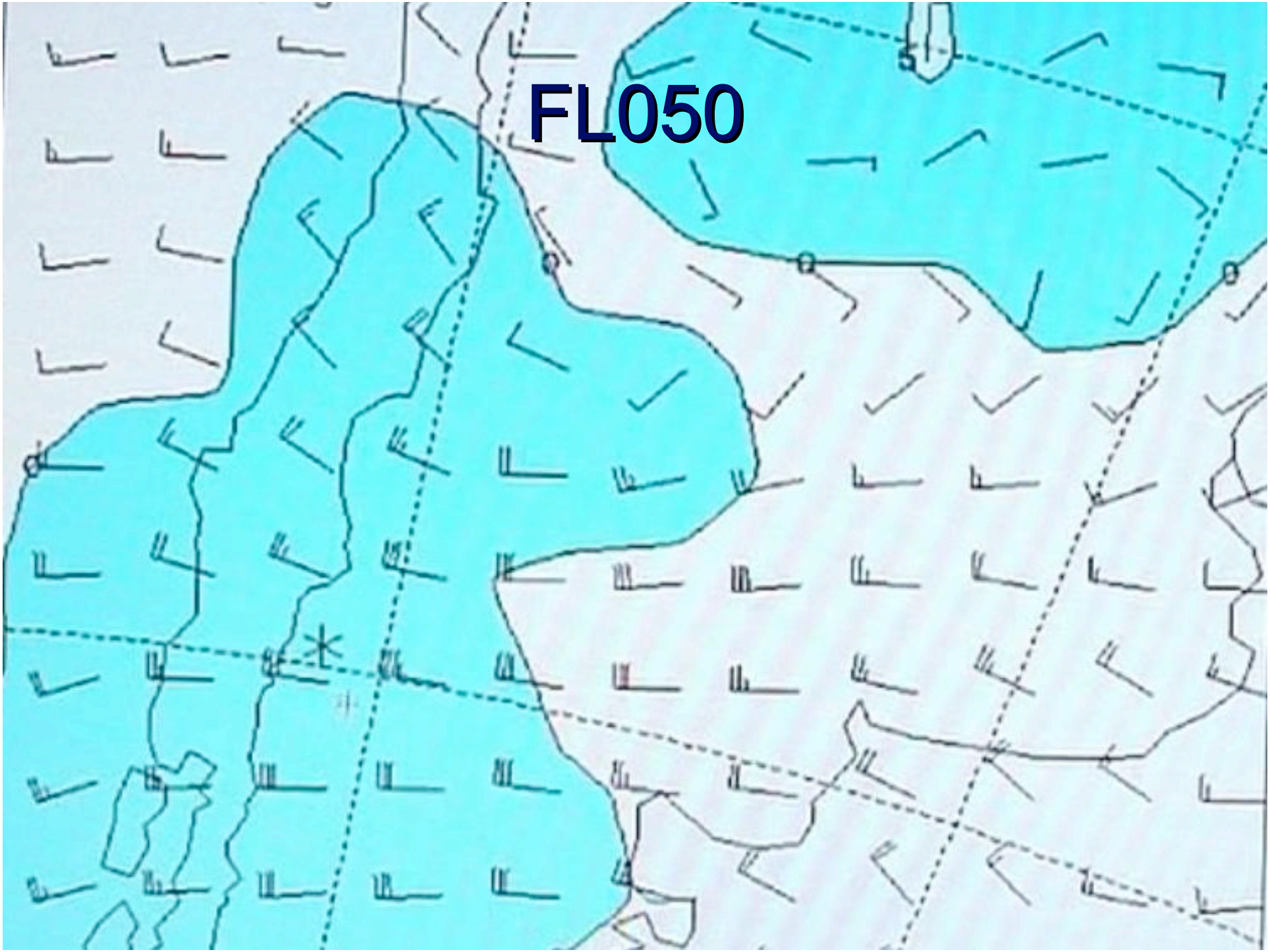
YOUR RECORD BREAKING FLIGHT IN A SINGLE-PLACE GLIDER -- 45,000 FEET - IS A NOTEWORTHY ADDITION TO THE ANNALS OF AVIATION PROGRESS. CONGRATULATIONS AND BEST WISHES ON YOUR ACHIEVEMENT

N E HALABY ADMINISTRATOR FAA.

1058A PST MAR 14 61

Clips from Argentina, Gliding in the 5th Dimension, 3000 km in a glider

- Have asked for permission to use this DVD but have not received the permission yet. This slide will be removed if permission is not received prior to release and presentation.
- Following 8 slides are also from this DVD and will be removed if permission is not granted as well.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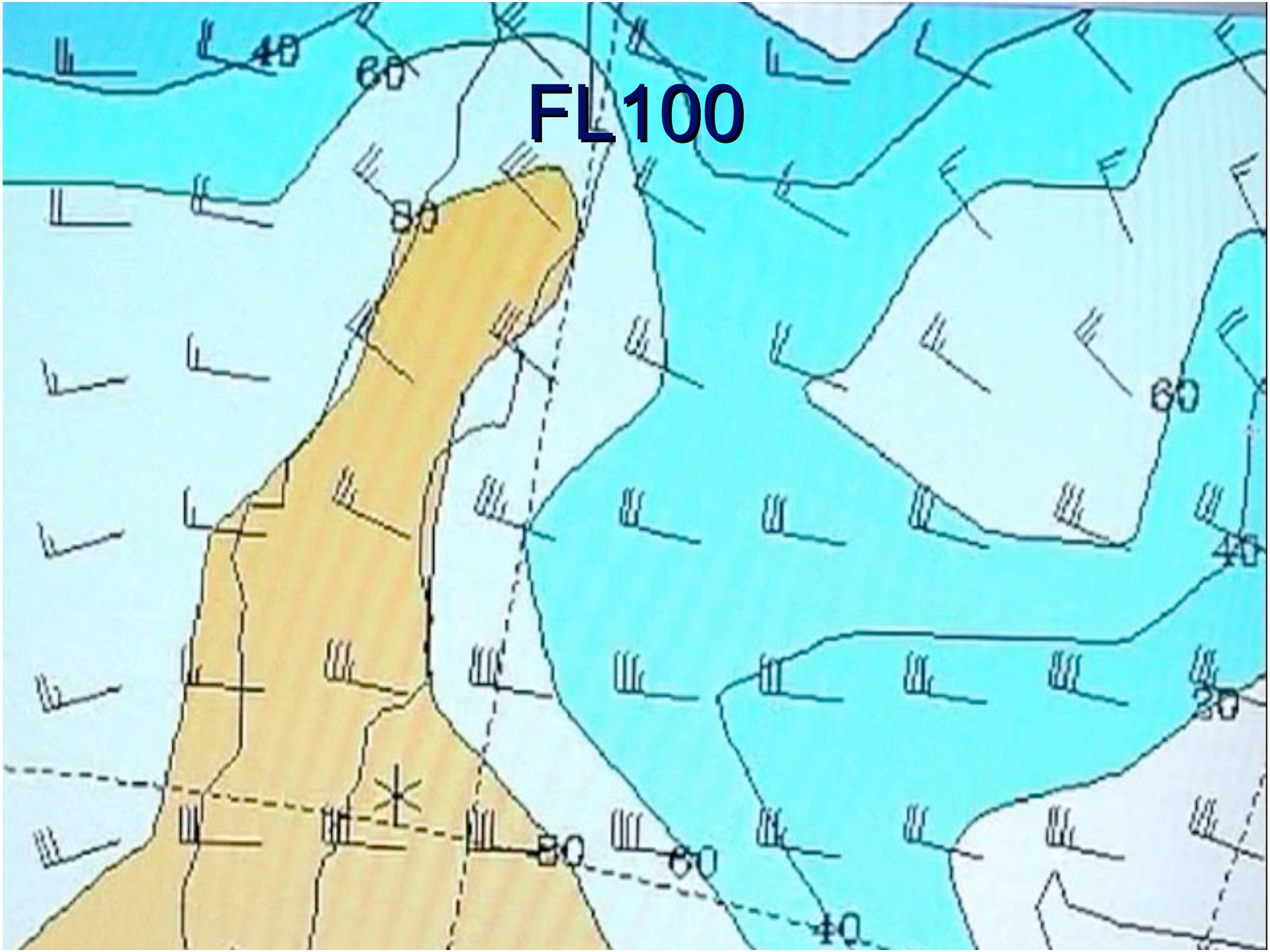
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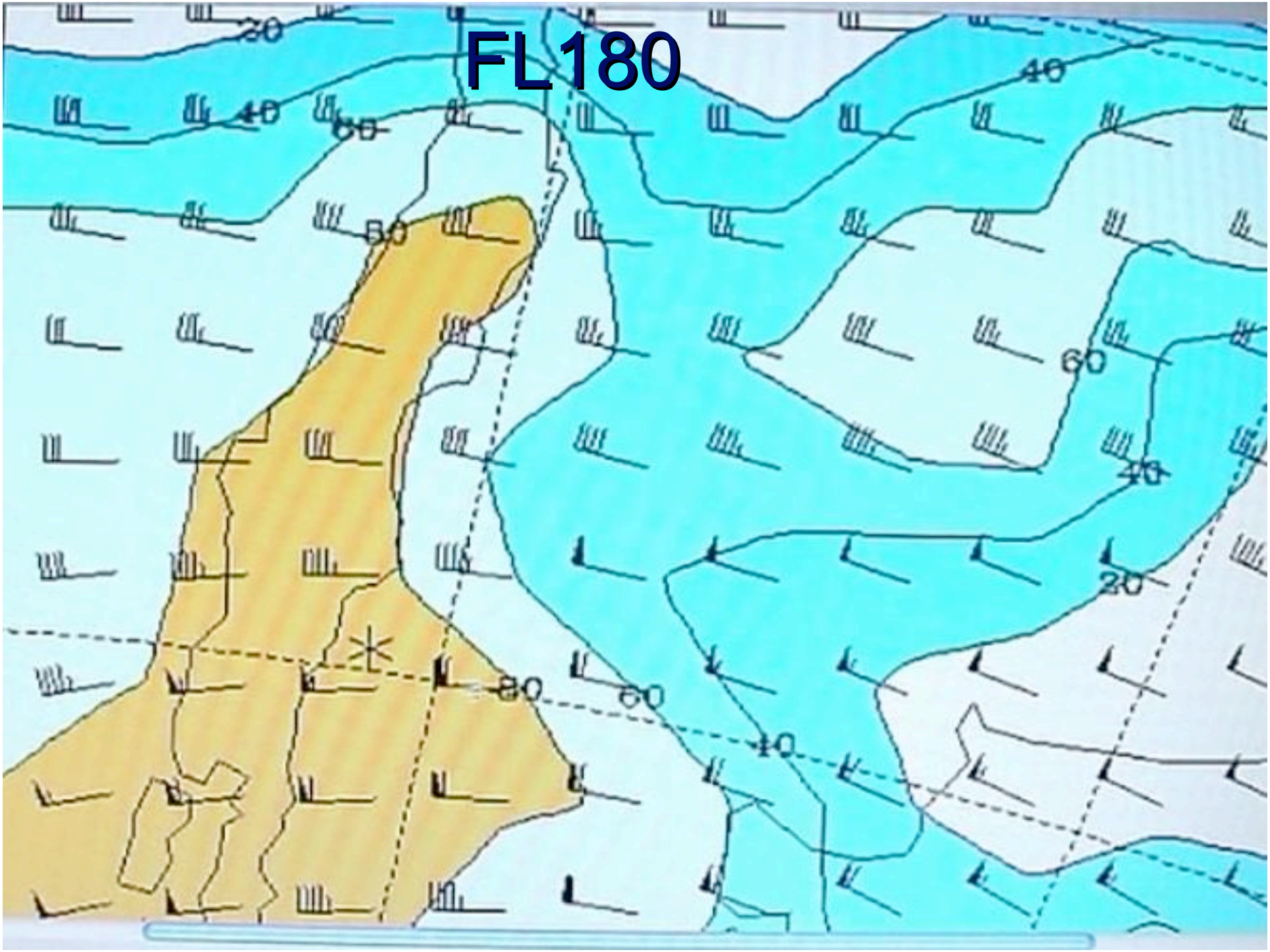
FL180
20
40
60
80
60
40
60
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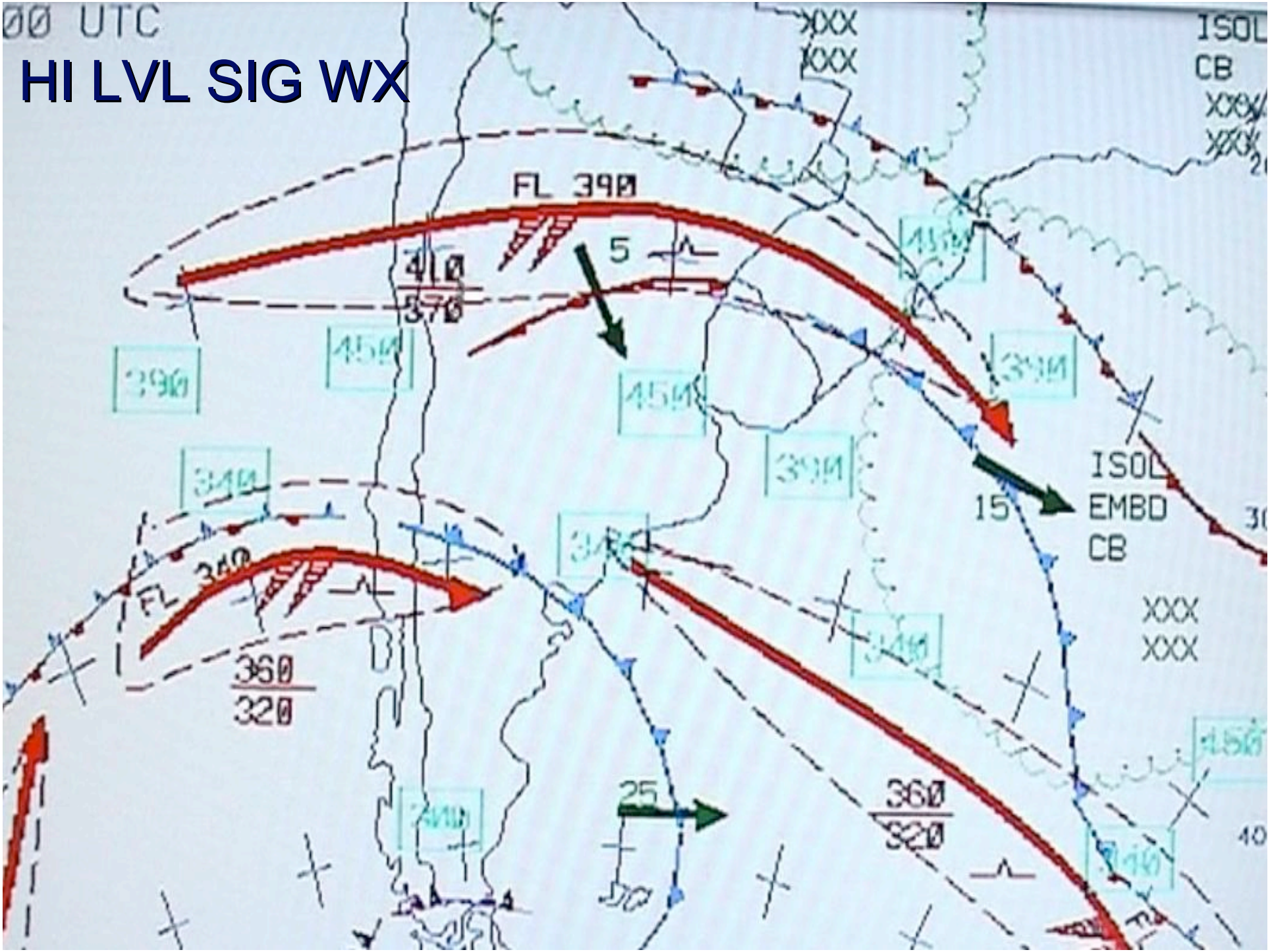
20
80
60
40


00 UTC
HI LVL SIG WX
FL 390
410
370
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ISOL
CB
XXX
XXX
ISOL
EMBD
CB
15
FL 340
360
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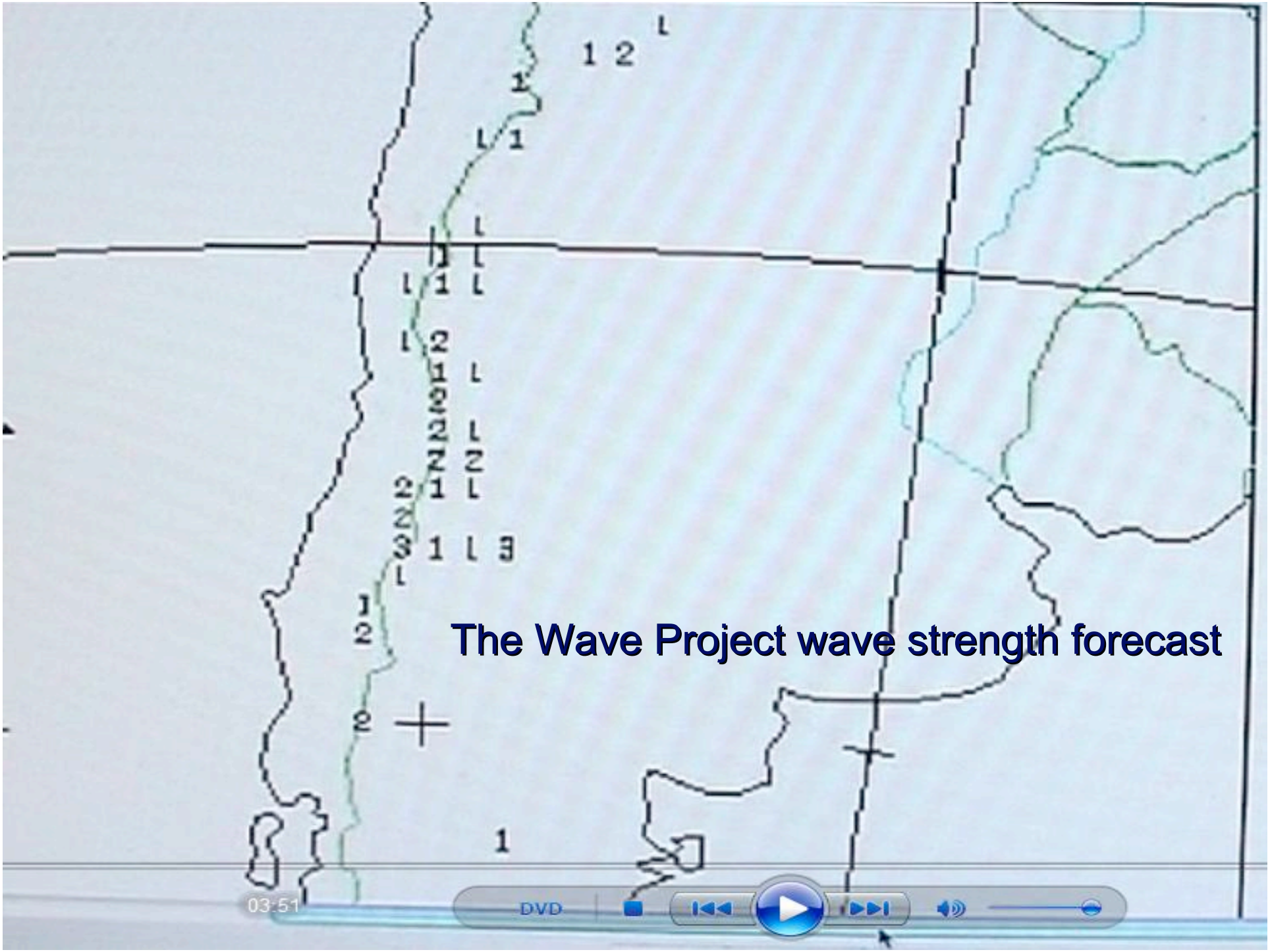
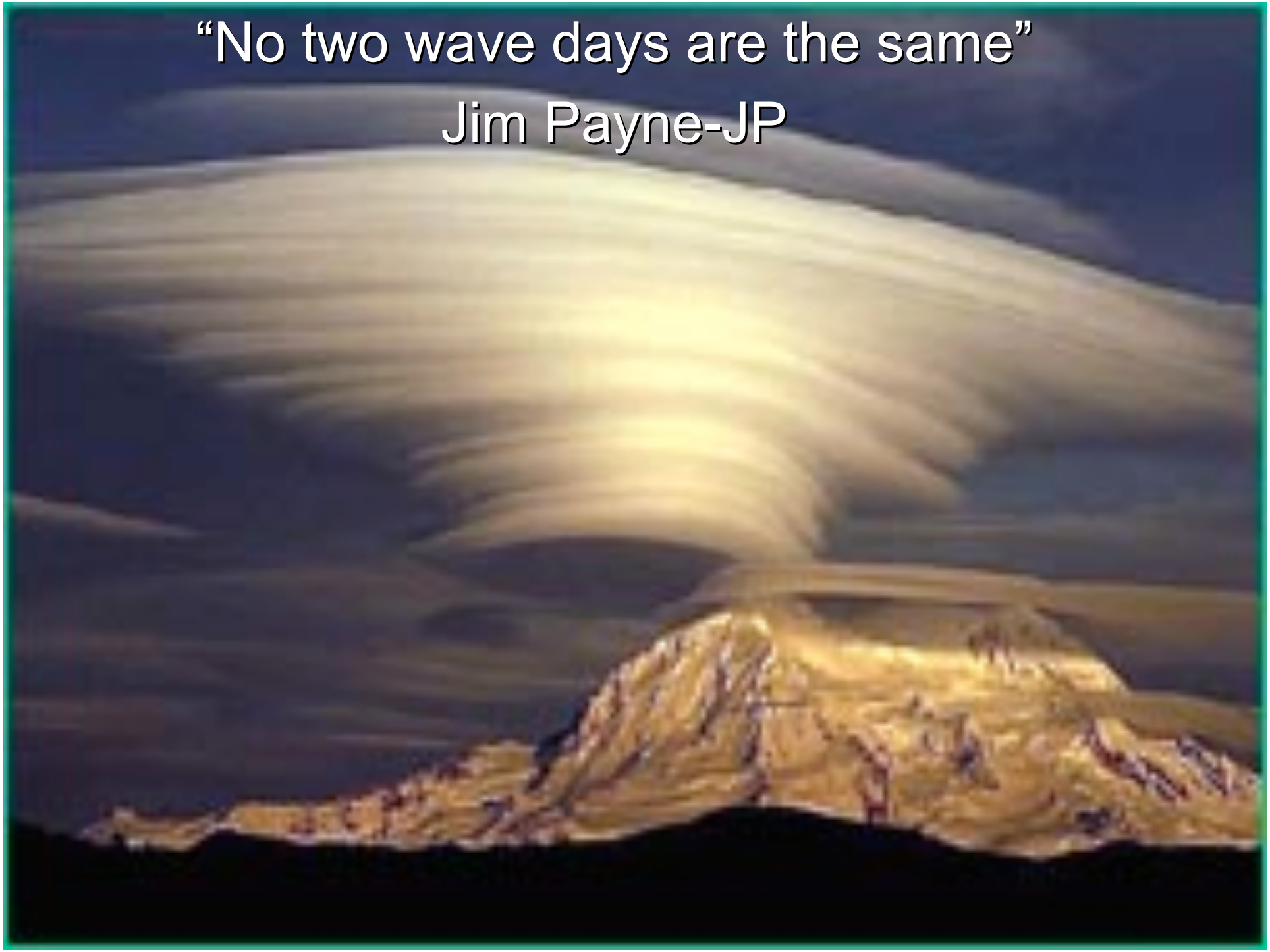
25
360
320
XXX
XXX


The Wave Project wave strength forecast
03:51
DVD


6-8am


“No two wave days are the same”
Jim Payne-JP

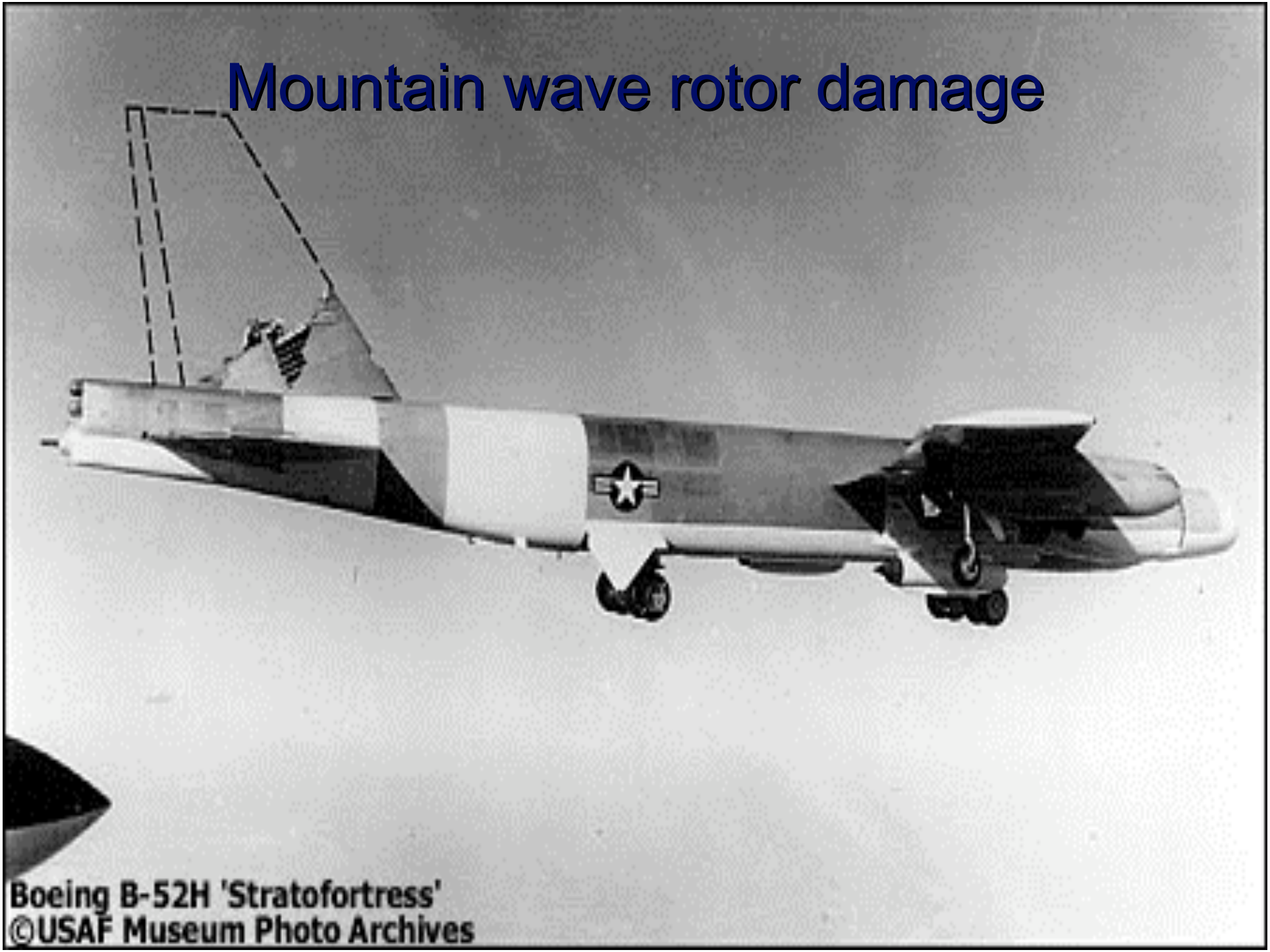
λ-Mountain Wave Wavelengths

- λ = Wave length = 0.6 U -3
- λ -where U is wind speed at the mountain top in meters per second
- λ -wavelength is in kilometers
- λ Probably the reason for the maximum wave lift leaning into the wind at high altitudes
- λ If lift is lost move upwind when windspeeds decrease or go downwind to the secondary wave crest

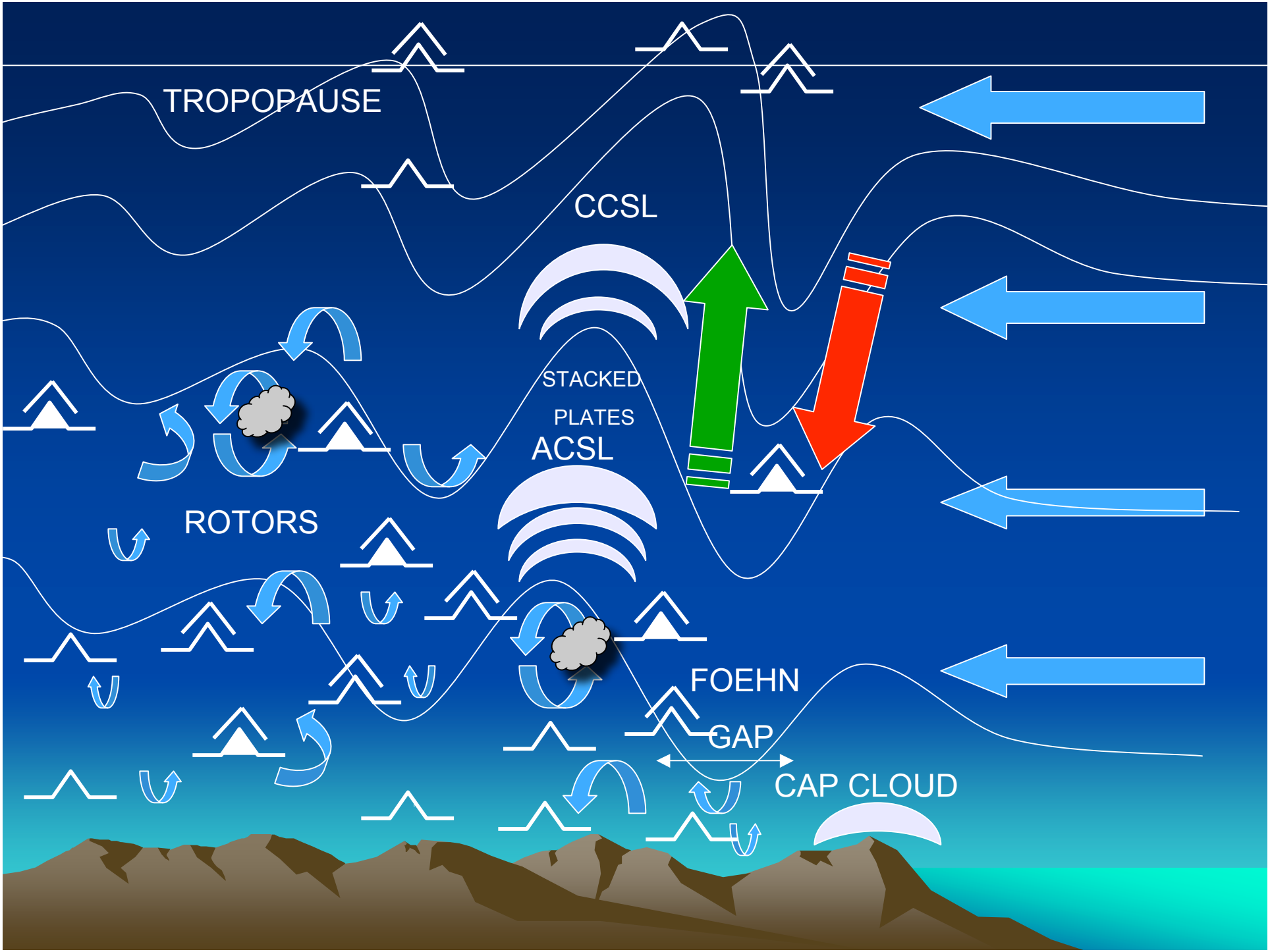
Long mountain waves: long flights

- Ten Longest Mountain Ranges
  - Andes: 4,500 miles
  - Rocky Mountains: 3,000 miles
  - Himalayas: 2,400 miles
  - Great Dividing Range: 2,250 miles
  - Transantarctic Mountains: 2,200 miles
  - Brazilian Coastal Range: 1,900 miles
  - Sumatra-Java Range: 1,800 miles
  - Aleutian Range: 1,650 miles
  - Tien Shan: 1,400 miles
  - New Guinea Range: 1,250 miles
- Canadian and US Sierras?

Mountain wave rotor damage



Boeing B-52H 'Stratofortress'
©USAF Museum Photo Archives


TROPOPAUSE
CCSL
STACKED
PLATES
ACSL
ROTORS
FOEHN
GAP
CAP CLOUD

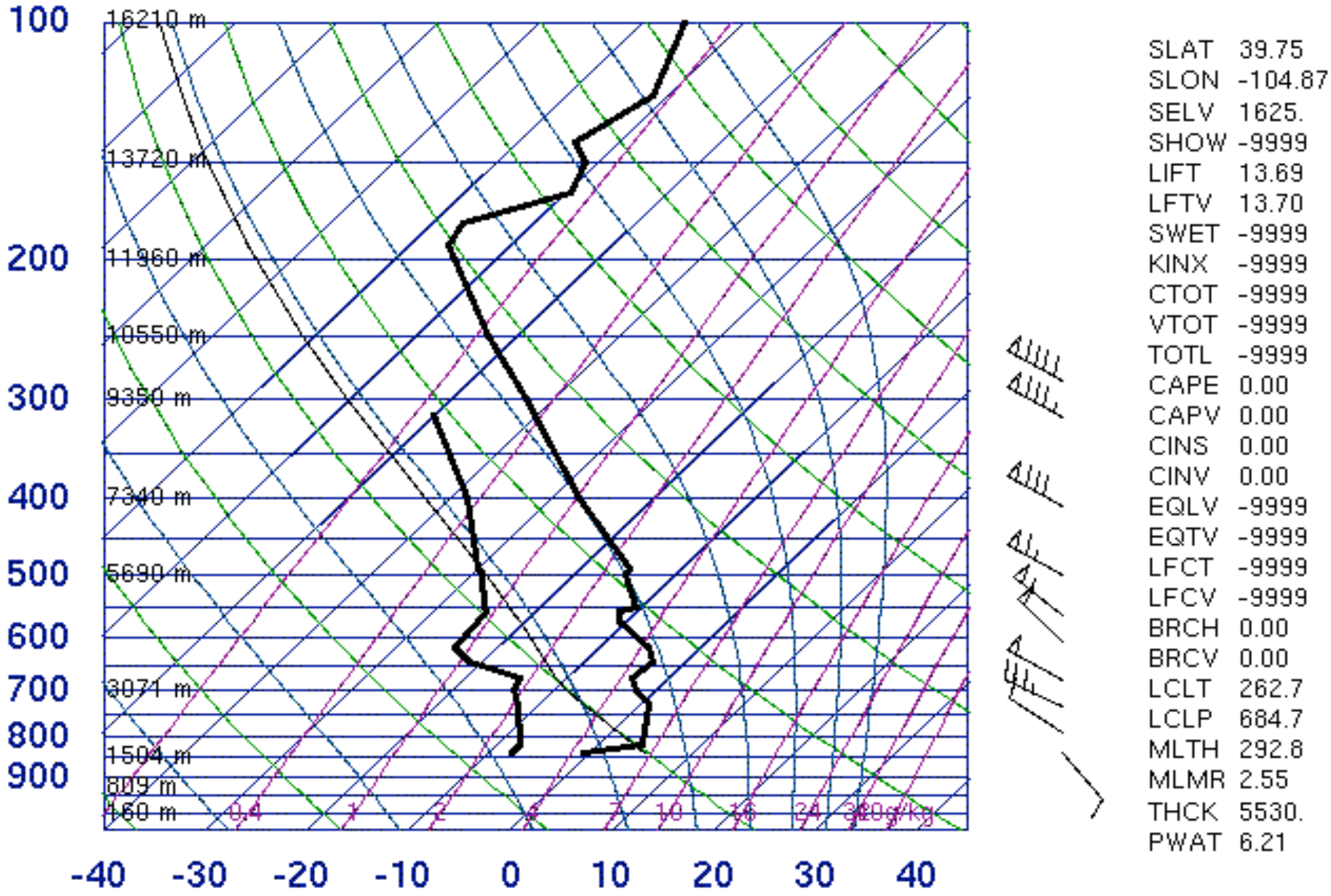
THE DENVER POST Thursday, December 10, 1992

The Denver Post / Kent Meireis

EMERGENCY LANDING: The damaged DC-8 cargo jet landed safely at Stapleton Airport yesterday morning.

Jet lands minus engine, wing tip

72469 DNR Denver



SLAT	39.75
SLON	-104.87
SELV	1625.
SHOW	-9999
LIFT	13.69
LFTV	13.70
SWET	-9999
KINX	-9999
CTOT	-9999
VTOT	-9999
TOTL	-9999
CAPE	0.00
CAPV	0.00
CINS	0.00
CINV	0.00
EQLV	-9999
EQTV	-9999
LFCT	-9999
LFCV	-9999
BRCH	0.00
BRCV	0.00
LCLT	262.7
LCLP	684.7
MLTH	292.8
MLMR	2.55
THCK	5530.
PWAT	6.21

12Z 10 Dec 1992

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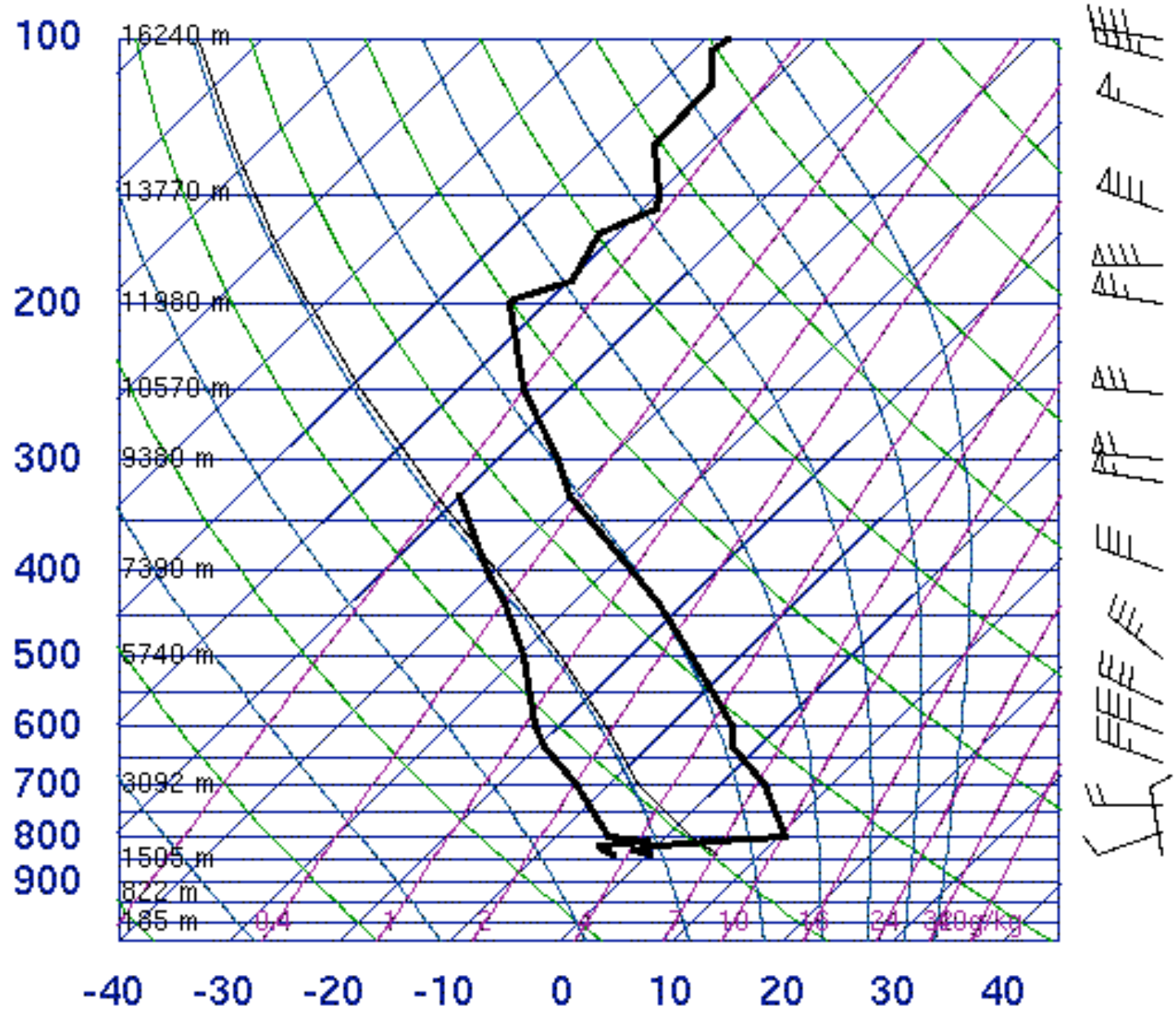
72469 DNR Denver



SLAT	39.75
SLON	-104.87
SELV	1625.
SHOW	-9999
LIFT	11.77
LFTV	11.73
SWET	-9999
KINX	-9999
CTOT	-9999
VTOT	-9999
TOTL	-9999
CAPE	0.00
CAPV	0.00
CINS	0.00
CINV	0.00
EQLV	-9999
EQTV	-9999
LFCT	-9999
LFCV	-9999
BRCH	0.00
BRCV	0.00
LCLT	267.2
LCLP	719.3
MLTH	293.6
MLMR	3.46
THCK	5555.
PWAT	7.10

00Z 11 Dec 1992

University of Wyoming

WHILE IN CRUISE FLIGHT AT FLIGHT LEVEL 310, 20 MILES WEST OF DENVER, COLORADO, THE ALL CARGO 14 CFR PART 121 FLIGHT ENCOUNTERED SEVERE CLEAR AIR TURBULENCE WHICH CAUSED MAJOR FLUCTUATIONS IN SPEED AND OSCILLATIONS IN BOTH PITCH AND ROLL. DURING THESE DEPARTURES FROM CONTROLLED FLIGHT, THE NUMBER ONE ENGINE AND 19 FEET OF THE LEADING EDGE OF THE LEFT WING SEPARATED FROM THE AIRCRAFT. IN ADDITION, THE NUMBER FOUR ENGINE PYLON CRACKED AND EXPERIENCED SUBSTANTIAL STRUCTURAL DAMAGE. THE FLIGHT CONDUCTED A PRECAUTIONARY DESCENT AND LANDED AT STAPLETON INTERNATIONAL AIRPORT, DENVER, COLORADO. PRECEDING THE OCCURRENCE, THE FLIGHT WAS ENCOUNTERING LIGHT TO OCCASIONALLY MODERATE CHOP, WITH MODERATE TO SEVERE TURBULENCE FORECAST.

MOUNTAIN WAVE TURBULENCE OPERATIONAL HAZARDS TURBINE POWERED

- REDUCE SPEED TO BELOW V_A
- TURN ON IGNIGHTERS BEFORE TURBULENCE PENETRATION
  - TO ASSIST IF THE TURBULENCE DISRUPTS THE AIRFLOW TO THE ENGINES AND ASSIST IF RESTART IS NECESSARY
  - SEVERE TURBULENCE COULD CAUSE ENGINE FLAMEOUT

Record soaring flights in MTN WV

- Combination of polar and subtropical Jets
- Speed tasks do not require upper level support
- Altitude records require a very high Tropopause
- Years of study, preparation and a great deal of knowledge of meteorology and weather support required
- A broad spectrum of mountain waves can be used to obtain world records
- Good soaring techniques are required but with determination and planning, even lower time pilots can become record setters

FURTHER STUDIES

- Get igc flight files and map record flights to the terrain and flight winds in See you
- Velocity limits for good wave on Polar and Subtropical jetstream flow **(usually <150knots)**
- Height of the surfaced based inversion in relation to mountain peaks is a key
- Braking waves must be understood and forecasted better

QUESTIONS?

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